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# COMPREHENSIVE AIR QUALITY AND METEOROLOGICAL MONITORING PROGRAM CONTRACT NO. DAAA15-88-D-0022 AIR QUALITY DATA ASSESSMENT REPORT FOR FY91 VOLUME I FINAL VERSION



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# COMPREHENSIVE AIR QUALITY AND METEOROLOGICAL MONITORING PROGRAM
# CONTRACT NO. DAAA15-88-D-0022
# AIR QUALITY DATA ASSESSMENT REPORT FOR FY91
# VOLUME I
# FINAL VERSION

**Prepared by:**
**WOODWARD-CLYDE CONSULTANTS**
**Prepared for:**
**U.S. ARMY PROGRAM MANAGER'S OFFICE FOR ROCKY MOUNTAIN ARSENAL**

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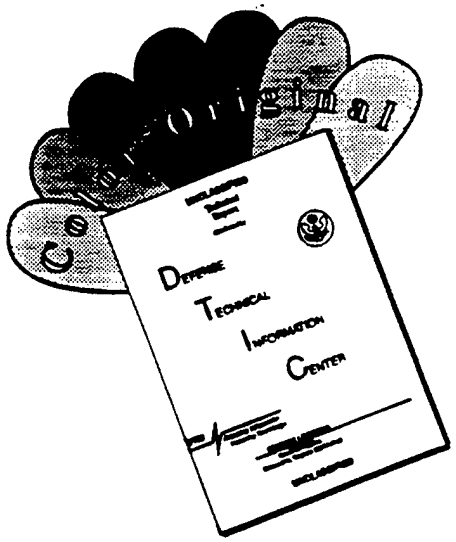


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THIS REPORT FOCUSES ON RESULTS OF THE CMP FOR FY91 AND INCLUDES ANALYSES AND COMPARISONS TO DATA FOR PRECEDING MONITORING PROGRAMS AT RMA AND FOR OTHER PROGRAMS WHICH RAN CONCURRENTLY. THE CMP FY91 DATA, IN CONJUNCTION WITH CMP FY88, FY89 AND FY90 DATA, BASIN F REMEDIAL MONITORING PROGRAM DATA, AND BASIN F POST-REMEDIAL IRA-F MONITORING PROGRAM DATA PROVIDE COMPREHENSIVE DATABASE FOR EVALUATING REMEDIAL PROGRESS RESULTING FROM THE BASIN F CLEANUP PROGRAM. ONE OBJECTIVE OF THIS REPORT IS TO PROVIDE AN ASSESSMENT OF THE COMBINED DATABASE IN THE CONTEXT OF REMEDIAL PROGRESS. (THIS REPORT CONSISTS OF FOUR VOLUMES AND TWO HIGH DENSITY DISKETTES CONTAINING THE MAJORITY OF THE TABLES PRESENTED IN VOLUME IV.)



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| | |
|---|---|
| 111TCE | 1,1,1-Trichloroethane |
| 112TCE | 1, 1,2-Trichloroethane |
| ACGIH | American Council of Governmental Industrial Hygienists |
| ADI | Acceptable Daily Intake |
| Atrazine | 2-chloro-4-ethylamino-6-isopropylamino-s-trianine |
| BCHPD | Bicycloheptadiene |
| CAQMMP | Comprehensive Air Quality and Meteorological Monitoring Program |
| $C_6H_6$ | Benzene |
| $CCl_4$ | Carbon Tetrachloride |
| CCM | Cubic Centimeters per Minute |
| CDH | Colorado Department of Health |
| CFM | Cubic Feet per Minute |
| $CH_2Cl_2$ | Methylene Chloride |
| $CHCl_3$ | Chloroform |
| Chlordane | 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methano-IH-indene |
| $ClC_6H_5$ | Chlorobenzene |
| CMP FY90 | Comprehensive Monitoring Program Fiscal Year 1990 |
| CO | Carbon Monoxide |
| CRL | Certified Reporting Limit |
| CVAAS | Cold Vapor Atomic Absorption Spectroscopy |
| DBCP | Dibromochloropropane |
| DCLE11 | 1,1-Dichloroethane |
| DCLE12 | 1,2-Dichloroethane |
| DCPD | Dicyclopentadiene |
| DDD | Dichlorodiphenyidichloroethane |
| DIMP | Diisopropylmethyl phosphonate |
| DMB12 | Dimethylbenzene |
| DMDS | Dimethyl Disulfide |
| DMMP | Dimethylmethyl phosphate |
| EPA | Environmental Protection Agency |
| $ETC_6H_5$ | Ethylbenzene |
| GC/MS | Gas Chromatography/Mass Spectrometry |
| GC/ECD | Gas Chromatography/Electron Capture Detection |
| HEAST | Health Effects Assessment Summary Table |
| ICAP/ICP | Inductively Coupled Argon Plasma |
| IRA-F | Interim Response Action at Basin F |
| IRDMS | Installation Restoration Data Management System |
| IRIS | Integrated Risk Information System |
| ISC | Industrial Source Complex Dispersion Model |

| | |
|---|---|
| Malathion | 0,0-dimethyl-s-(1,2-dicarboxyethyl) phosphorodithioate |
| $MEC_6H_5$ | Toluene |
| MIBK | Methyl Isobutyl Ketone |
| MRI | Midwest Research Institute |
| MST | Mountain Standard Time |
| NAAQS | National Ambient Air Quality Standards |
| NATICH | National Air Toxics Information Clearinghouse |
| NIOSH | National Institute of Occupational Safety and Health |
| NNDMEA | N-Nitrosodimethylamine |
| NO | Nitric Oxide |
| $NO_2$ | Nitrogen Dioxide |
| $NO_x$ | Nitrogen Oxides |
| $O_3$ | Ozone |
| OCP | Organochlorine Pesticides |
| Parathion | Parathion ($C_{10}H_{14}NO_5PS$) |
| PMRMA | Program Manager Rocky Mountain Arsenal |
| PM-10/$PM_{10}$ | Respirable Particulates less than 10 microns |
| PPDDE | Dichlorodiphenylethane |
| PPDDT | Dichlorodiphenyltrichloroethane |
| PSD | Prevention of Significant Deterioration |
| PUF | Polyurethane Foam |
| QA | Quality Assurance |
| QC | Quality Control |
| RBACs | Risk-Based Air Concentrations |
| RfCs | Reference Concentrations |
| RMA | Rocky Mountain Arsenal |
| SARA | Superfund Amendments and Reauthorization Act |
| SCCM | Standard Cubic Centimeters per Minute |
| SCFM | Standard Cubic Feet per Minute |
| $SO_2$ | Sulfur Dioxide |
| Supona | 2-chloro-1-(2,4-dichlorophenyl) vinyl diethyl phosphate |
| SVOC | Semi-Volatile Organic Compounds |
| T12DCE | Trans-1,2-Dichloroethene |
| TCLEE | Tetrachloroethene |
| TIC | Tentatively Identified Compound |
| TLV | Threshold limit value |
| tpy | tons per year |
| TRCLE | Trichloroethene |
| TSP | Total Suspended Particulates |
| UCRL | Upper Certified Reporting Limit |
| UNK | Unknown number |
| USATHAMA | U.S. Army Toxic and Hazardous Materials Agency |
| USAEHA | U.S. Army Environmental Hygiene Agency |

| | |
|---|---|
| VOC | Volatile Organic Compounds |
| XYLENE | Xylene |

The purpose of the Air Monitoring Element of the Comprehensive Monitoring Program (CMP) at the Rocky Mountain Arsenal (RMA) is to continue the ongoing collection of baseline data that was established under the Remedial Investigation Program. The program is used to determine ambient air quality levels at RMA in support of remedial actions and as a guide to evaluate progress. The CMP has several related key objectives: (1) to verify and evaluate potential air quality health hazards; (2) to verify progress that has been made to date in removing air contaminants resulting from previous activities; (3) to provide baseline data for the evaluation of progress that will be made in future remedial activities; (4) to develop real-time guidelines, standard procedures and data collection methods, as appropriate, to indicate impacts of ongoing remedial actions; and (5) to validate and document database reliability.

The CMP comprises a network of fixed and portable monitoring stations that collect air samples and measure the following analytes:

Total suspended particulates (TSP)
Respirable particulates less than 10 microns (PM-10)
Volatile organic compounds (VOC)
ICP Metals (cadmium, chromium, copper, lead and zinc)
Mercury
Arsenic
Asbestos
Organochlorine pesticides (OCP)
Carbon monoxide
Nitrogen oxides
Ozone
Sulfur dioxide

The CMP consists of three modes of operation: (1) routine baseline monitoring of PM-10, VOC, total suspended particulates (TSP), organochlorine pesticides (OCP), asbestos, specified metals, and gaseous pollutants; (2) "high event" monitoring during

specified meteorological conditions to measure peak concentrations of VOC, OCP, arsenic and metals; and (3) remedial monitoring coordination and direct support, as may be appropriate, to standardize and supplement air monitoring procedures for on-site remedial and construction activities.

This report focuses on results of the CMP for FY91 and includes analyses and comparisons to data for preceding monitoring programs at RMA and for other programs which ran concurrently. The CMP FY91 data, in conjunction with CMP FY88, FY89 and FY90 data, Basin F Remedial Monitoring Program data, and Basin F post-remedial IRA-F Monitoring Program data provide comprehensive database for evaluating remedial progress resulting from the Basin F cleanup program. One objective of this report is to provide an assessment of the combined data base in the context of remedial progress.

Data analyses characterized potential sources for air contaminants which were observed, including both RMA and metropolitan Denver influences. On-site meteorological data and ambient visibility observations were also used to describe those conditions associated with the average and the extreme events. Dispersion modeling was used as a tool to evaluate whether a source potentially contributed to observed ambient air concentrations.

The following discussion summarizes the results of the analyses for each group of air quality parameters.

Total Suspended Particulates

TSP levels at RMA can be attributed to two principal sources: (1) the influx of particulates from metropolitan Denver, and (2) remedial activity sources which helped to produce wind-blown dust, particularly during very dry episodes. The distribution of the TSP concentration data clearly reflect the impact of Basin F remedial activities, with dramatic decreases in TSP levels around Basin F after the conclusion of remedial activities. During the height of these activities, the TSP levels which could be attributed to remediation activities decreased significantly with distance from the basin. This feature was observed both in the FY88 and FY89 data. During FY90, other construction

activities at RMA, such as in the vicinity of the Lower Derby Lake spillway, produced noticeable TSP impacts; again these were highly localized and decreased rapidly from the source. In addition, there were several episodes during which impacts from metropolitan Denver completely overwhelmed impacts from potential on-site sources. During FY91, other isolated RMA activities that temporarily disturbed surface soils contributed to a small number of measured, elevated TSP concentrations at the RMA monitoring stations. In general, TSP concentration distribution was similar between FY90 and FY91. At the eastern and northern boundaries of RMA, the TSP levels were well below those of metropolitan Denver, and were more representative of rural conditions.

Respirable Particulates (PM-10)

Respirable particulates are generated at RMA by dry windy conditions, but to a much lesser extent than for TSP. There were no violations of the annual or 24-hour PM-10 standards at RMA during FY90 or FY91. The high PM-10 levels at RMA could be related to relatively high PM-10 levels in metropolitan Denver. Remediation activities played a minor role in increasing PM-10 levels during local remediation and construction activities. Impacts also decreased rapidly with distance from the potential source.

Metals

Ambient concentrations of metals across RMA were generally proportional to levels of TSP. Maximum concentrations were sampled on high wind speed days and also when there were high TSP and PM-10 levels, which in turn were attributed to sources off the Arsenal. During remediation activities, Basin F appeared to be a source of mercury, chromium, copper and zinc, and these concentrations decreased rapidly with distance from Basin F. Following closure of the basin, the metals levels were reduced to those typical of baseline conditions. Isolated concentration maxima of chromium, cadmium and copper, relative to average post-remedial concentrations, were measured during FY91 which do not appear to be directly attributable to RMA sources.

Asbestos

Asbestos was detected twice at RMA during FY91 at sites AQ6 and AQ8 on the same sampling date. No detections of asbestos occurred during FY88 and FY90, and only two days with detections occurred during FY89.

Volatile Organic Compounds

During the Basin F remediation, on-site activities appeared to be a source of several volatile organic compounds, including bicycloheptadiene, dimethyl disulfide, benzene, toluene, and ethylbenzene. The source of these compounds could have resulted from the emissions from heavy equipment which was used during remediation. Chloroform was identified near both Basin F and the South Plants. Levels of VOCs which were attributed to RMA sources during the Basin F remediation period decreased rapidly with distance from those sources, and levels at RMA boundaries were similar to or less than those within the urban environment of metropolitan Denver. During FY89, FY90 and FY91, monitored concentrations of many of the VOCs attributed to Basin F decreased significantly. During FY91, most of the VOC concentrations measured at RMA monitoring sites were attributed to close-by off-Arsenal sources since observed VOC concentration distributions did not conform to those expected when a RMA source is the primary influence.

Semi-Volatile Organic Compounds

Basin F appeared to be a source of several semivolatile organic compounds, including aldrin, dieldrin, and endrin during the Basin F remediation period. The highest levels were detected in the immediate vicinity of Basin F during these remediation efforts. Results from a location downwind from the basin at the northeast perimeter of Basin F showed the highest levels of SVOCs, but at the RMA boundaries, these level were reduced to roughly background levels. During the FY89 and FY90 post-remediation periods, SVOC concentrations were reduced significantly in the vicinity of Basin F and all SVOC concentrations measured at other RMA (CMP) monitoring sites were close to background levels. With the decrease of most SVOC concentrations to background levels, the monitoring of SVOCs was limited to the OCP subset during FY91. Thus,

SVOC sampling during FY91 consisted of the OCPs only and were exclusively analyzed in the laboratory by the more sensitive method designed to detect lower concentrations.

Organochlorine Pesticides

During FY90, these compounds were at or near the detection limit at the RMA boundary sites. Highest levels were sampled during the Basin F remediation effort, and nearest to Basin F itself. Following the completion of the remedial activities, these levels were reduced to near background levels in the vicinity of Basin F as well. Highest OCP concentrations during FY90 and FY91 were measured at AQ3, suggesting a primary source north of RMA with potentially minor impacts from Basin F based on prevailing wind patterns.

Criteria Pollutants

Ambient concentrations of the criteria pollutants, including sulfur dioxide, nitrogen dioxide, carbon monoxide, and ozone were monitored continuously at RMA during FY91. Generally, the air quality at the RMA monitoring location was cleaner than that at other sites in the Denver area. Criteria pollutant concentrations monitored within RMA showed no violations of any applicable short-term or long-term standards. Episodes with relatively high concentrations at RMA were related to potential nearby sources under certain meteorological conditions. Most occurrences of relatively higher ambient concentrations within RMA appeared to be attributable to metropolitan Denver influences.

# 1.0
# INTRODUCTION

The purpose of the Air Monitoring Element of the Comprehensive Air Quality and Meteorological Monitoring Program (CAQMMP) at the Rocky Mountain Arsenal (RMA) is to continue the ongoing collection of baseline data that was established under the Remedial Investigation Program. The program is used to determine ambient air quality levels at RMA in support of remedial actions and as a guide to evaluate progress. The CAQMMP has several related key objectives: (1) to verify and evaluate potential air quality health hazards; (2) to verify progress that has been made to date in removing air contaminants resulting from previous activities; (3) to provide baseline data for the evaluation of progress that will be made in future remedial activities; (4) to develop real-time guidelines, standard procedures and data collection methods, as appropriate, to indicate impacts of ongoing remedial actions; and (5) to validate and document database reliability. The term, CAQMMP, will be used interchangeably with that portion of the program previously known as the Comprehensive Monitoring Program (CMP) and the integrated CMP/Interim Response Action at Basin F (IRA-F) program that commenced on January 24, 1991.

This is the fourth CMP report, covering FY91, that incorporates the last IRA-F monitoring period (October-December, 1990) and the integrated CAQMMP (January-September, 1991). The first three CMP reports (CMP FY88, CMP FY89, and CMP FY90) comprised annual periods (RLSA 1989, 1990, and 1991). The FY90 program was concluded on September 30, 1990; however, the extension for the CMP was not authorized until January 1991. In the interim, IRA-F monitoring was continued until mid-January, 1991. The integrated CMP and IRA-F programs, CAQMMP, was conducted between January 24 and September 30, 1991. The FY91 program included all previous CMP monitoring activities (with certain modifications), in addition to the IRA F program, which incorporated more intensive monitoring in the vicinity of the Basin F remediation site. Details of the FY91 program are provided in Section 3.

In the previous CMP reports, both CMP and Basin F/IRA-F data were compared chronologically and spatially in order to assess impacts from Basin F activities during the

remedial and post-remedial periods. The IRA-F program was originally scheduled to be terminated on September 30, 1990, but was extended to January 18, 1991. A separate report contains data results and assessments through September 1990 (Ebasco, 1991). Data collected under the IRA-F program after that date are contained in this report. Although there is a gap in CMP data from September 30, 1990, to January 24, 1991, the IRA-F data provide continuity of the program across the more sensitive areas of RMA.

Emphasis in this FY91 report is placed on documenting the routine and high event air quality and meteorological monitoring data collected during the extension period. The intention of this report is to provide a comprehensive assessment of these results. Comparisons with National Ambient Air Quality Standards (NAAQS) are provided to highlight or clarify results, where applicable. For those compounds considered as toxic, detailed comparisons to available health and safety guideline values are provided. Results of data summaries of total suspended particulates (TSP), respirable particulates less than 10 microns (PM-10), volatile organic compounds (VOC), asbestos, metals, mercury and organochlorine pesticides (OCP) for CMP FY91 and the IRA-F Monitoring Program (October 1990 through January 1991) are provided in appropriate sections of the report; all sequential data are provided in appendices.

The CMP comprises a network of fixed and portable monitoring stations that collect air samples and measure the following analytes:

Total suspended particulates (TSP)
Respirable particulates less than 10 microns (PM-10)
Volatile organic compounds (VOC)
ICP Metals (cadmium, chromium, copper, lead and zinc)
Mercury
Arsenic
Asbestos
Organochlorine Pesticides (OCP) - formerly referred to as OTSP
Organic Vapors (using real-time OVA/HNu analyzers)
Carbon monoxide
Oxides of nitrogen

Ozone
Sulfur dioxide

The CMP consists of three modes of operation: (1) routine baseline monitoring of PM-10, VOC, TSP, OCP, asbestos, specified metals, and gaseous pollutants; (2) "high event" monitoring during specified meteorological conditions to measure peak concentrations of VOC, OCP, arsenic and metals; and (3) remedial monitoring coordination and direct support, as may be appropriate, for on-site remedial and construction activities and post-remedial assessment. For example, during the FY91 period, the CMP assumed responsibility for IRA-F post-remedial monitoring in the vicinity of Basin F; weekly sampling was conducted for off-gases from an air stripper associated with ground-water extraction near Basin F. Monitoring of all parameters was also conducted routinely upwind and downward during the construction phase of the proposed quench incinerator facility. In addition, the program provides for maintaining the four tower meteorological network at RMA. Finally, the program provides for evaluation of the collected baseline and site-specific data so that it can be used in planning remedial actions and in assessing remedial progress.

Various background and reference materials relating to the CMP are available (Section 9.0), including the Final Technical Plan for Air Quality submitted by R. L. Stollar & Associates, Inc. (RLSA, 1990) and the CMP FY88, FY89 and FY90 Air Quality Data Assessment Reports (RLSA, 1990, 1991). These documents summarize several of the CMP's major considerations and elements, including: (1) the nature and background of RMA air quality concerns; (2) regional air quality and meteorological characteristics; (3) RMA air quality and meteorological characteristics; and (4) a description of the CMP sampling and analyses programs. As these elements were reviewed in some detail in past CMP reports, they will be further discussed in this report to indicate changes from previous operations or are important for direct reference in this report in the context of program continuity.

## 1.1 SITE BACKGROUND INFORMATION

RMA occupies over 17,000 acres (27 sq mi) northeast of Denver, Colorado in western Adams County (Figure 1.1-1). It was established in 1942, and was used to manufacture chemical and incendiary munitions, and to demilitarize chemical munitions. Additionally, industrial chemicals were manufactured at RMA from 1947 to 1982. A number of manufacturing, storage and transportation facilities were built and used throughout the years to support RMA activities. These identifiable RMA features were naturally perceived as potential contaminant sources, and their names along with the names of local geographic features are frequently used in discussing specific RMA areas (Figure 1.1-2). The history of RMA operations from the initiation of manufacturing in 1942 to the cessation of activities was discussed in detail in the previous CMP reports.

## 1.2 POTENTIAL CONTAMINANT SOURCES

Potential sources of airborne contaminants within RMA boundaries were identified, and air quality and meteorological monitoring stations were located near them, as shown in Figure 1.2-1. Previous air Monitoring studies and remedial investigations conducted at RMA indicated that major sources of potential airborne emissions existed from the South Plants area, through Sections 36 and 26, to Basin F. Because production and demilitarization activities have ceased, there are no longer discrete or point sources of emissions at RMA. Rather, the sources shown in Figure 1.2-1 are large area or potential fugitive sources whose emissions are a function of atmospheric conditions, surface cover, and the contaminants' physical state. These sources, under typical conditions, do not appear to pose a major problem; however, remediating these sources may create temporary problems with air quality. These conditions continue to be monitored under the CMP. An example of this is the Basin F Interim Action Remedial Cleanup Program. Although the liquid from Basin F has been removed and it no longer represents an uncontrolled source of several potential contaminants, air monitoring has continued in the vicinity of Basin F, both under the CMP and the Basin F follow-on IRA-F Monitoring Program. Extensive post-remedial monitoring in the vicinity of Basin F continued to be conducted during the FY91 program. The location of the initial Basin F source has been maintained in the various figures shown in this report in order to better

depict possible continuing impacts and remedial progress as a result of the cleanup activities.

Based upon historical records of disposal activities and chemical spills, the following general RMA areas have been suspected as potential sources of fugitive airborne emissions during the CMP FY88, FY89, FY90 and FY91 monitoring periods:

- South Plants manufacturing complex - Volatile and semi-volatile organic compounds (VOCs and SVOCS) and asbestos;
- Basin A - Semi-volatile organic compounds, metals and particulates; and
- Basin F - Volatile and semi-volatile organic compounds, metals and particulates.

During CMP FY91, routine and high event monitoring were conducted at each of these locations.

## 1.3 RESULTS OF CMP FY90 ASSESSMENT

Detailed discussions of previous CMP monitoring results are provided in the CMP FY88, FY89, and FY90 Air Quality Data Assessment Reports (RLSA, 1989, 1990, and 1991). A summary of the CMP FY90 report is presented to place the CMP FY91 results in proper perspective.

Total Suspended Particulates

TSP levels at RMA can be attributed to two principal sources: (1) the influx of particulates from metropolitan Denver, and (2) remedial activity sources which helped to produce wind-blown dust, particularly during very dry episodes. The TSP data clearly reflect the impact of Basin F remedial activities, with dramatic decreases in TSP levels around Basin F after the conclusion of remedial activities. During the height of these activities, the TSP levels which could be attributed to remediation activities decreased significantly with distance from the basin. This feature was observed both in the FY88

and FY89 data. During FY90, other construction activities at RMA, such as in the vicinity of the Lower Derby Lake spillway, produced noticeable TSP impacts; again these were highly localized and decreased rapidly from the source. In addition, there were several episodes during which impacts from metropolitan Denver completely overwhelmed impacts from potential on-site sources. At the eastern and northern boundaries of RMA, the TSP levels were well below those of metropolitan Denver, and were more representative of rural conditions.

Respirable Particulates (PM-10)

Respirable particulates are generated at RMA by dry windy conditions, but to a much lesser extent than for TSP. There were no violations of the annual or 24-hour PM-10 standards at RMA during FY90. The high PM-10 levels at RMA could be related to relatively high PM-10 levels in metropolitan Denver. Remediation activities played a minor role in increasing PM-10 levels during local remediation and construction activities. Impacts also decreased rapidly with distance from the potential source.

Metals

Ambient concentrations of metals across RMA were generally proportional to levels of TSP. Maximum concentrations were sampled on high wind speed days and also when there were high TSP and PM-10 levels, which in turn were attributed to sources off the Arsenal. During remediation activities, Basin F appeared to be a source of mercury, chromium, copper and zinc, and these concentrations decreased rapidly with distance from Basin F. Following closure of the basin, the metals levels were reduced to those typical of baseline conditions.

Asbestos

Asbestos was not detected at RMA during FY90. There were no detections of asbestos during FY88, and only two days with detections during FY89.

Volatile Organic Compounds

During the Basin F remediation, on-site activities appeared to be a source of several volatile organic compounds, including bicycloheptadiene, dimethyl disulfide, benzene, toluene, and ethylbenzene. Some of these emissions could have resulted from the emissions from heavy equipment which was used during remediation. Chloroform was identified near both Basin F and the South Plants. Levels of VOCs which were attributed to RMA sources during the Basin F remediation period decreased rapidly with distance from those sources, and levels at RMA boundaries were similar to or less than those within the urban environment of metropolitan Denver. During FY89 and FY90 many of the VOCs attributed to Basin F decreased significantly. During FY90, many of the VOCs measured at RMA monitoring sites were attributed to nearby off-Arsenal sources as identified in the FY90 report.

Semi-Volatile Organic Compounds

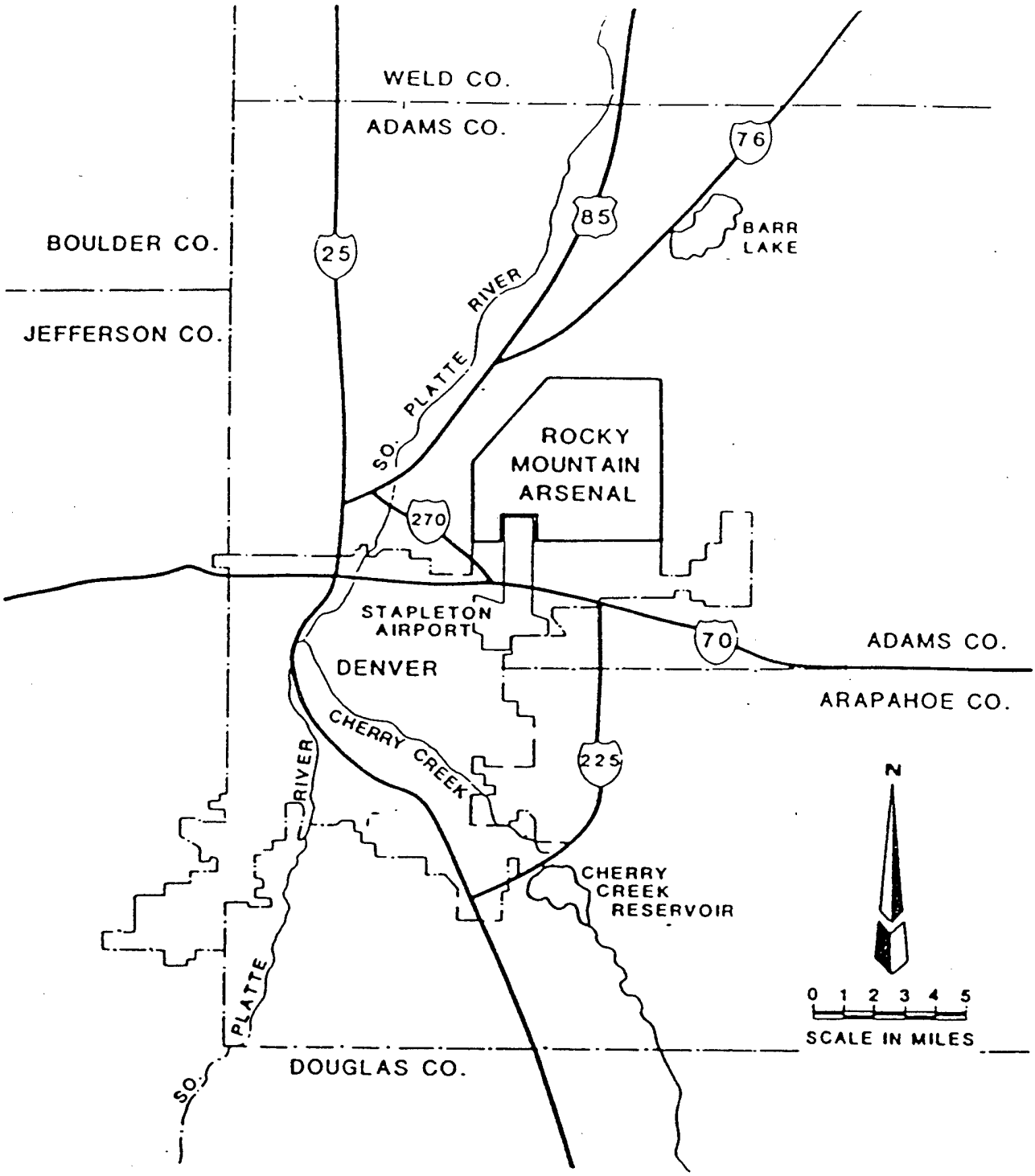
Basin F appeared to be a source of several semi-volatile organic compounds, including aldrin, dieldrin, and endrin during the Basin F remediation period. The highest levels were detected in the immediate vicinity of Basin F during these remediation efforts. Results from a location downwind from the basin at the northeast perimeter of Basin F showed the highest levels of SVOCS, but at the RMA boundaries, these levels were reduced to roughly background levels. During the FY89 and FY90 post-remediation periods, SVOC concentrations were reduced significantly in the vicinity of Basin F and all SVOC concentrations measured at other RMA (CMP) monitoring sites were close to background levels.

Organochlorine Pesticides

The organochlorine pesticide compounds were at or near the detection limit at the RMA boundary sites. Highest levels were sampled during the Basin F remediation effort, and nearest to Basin F itself. Following the completion of the remedial activities, these levels were reduced to near background levels in the vicinity of Basin F as well.

Criteria Pollutants

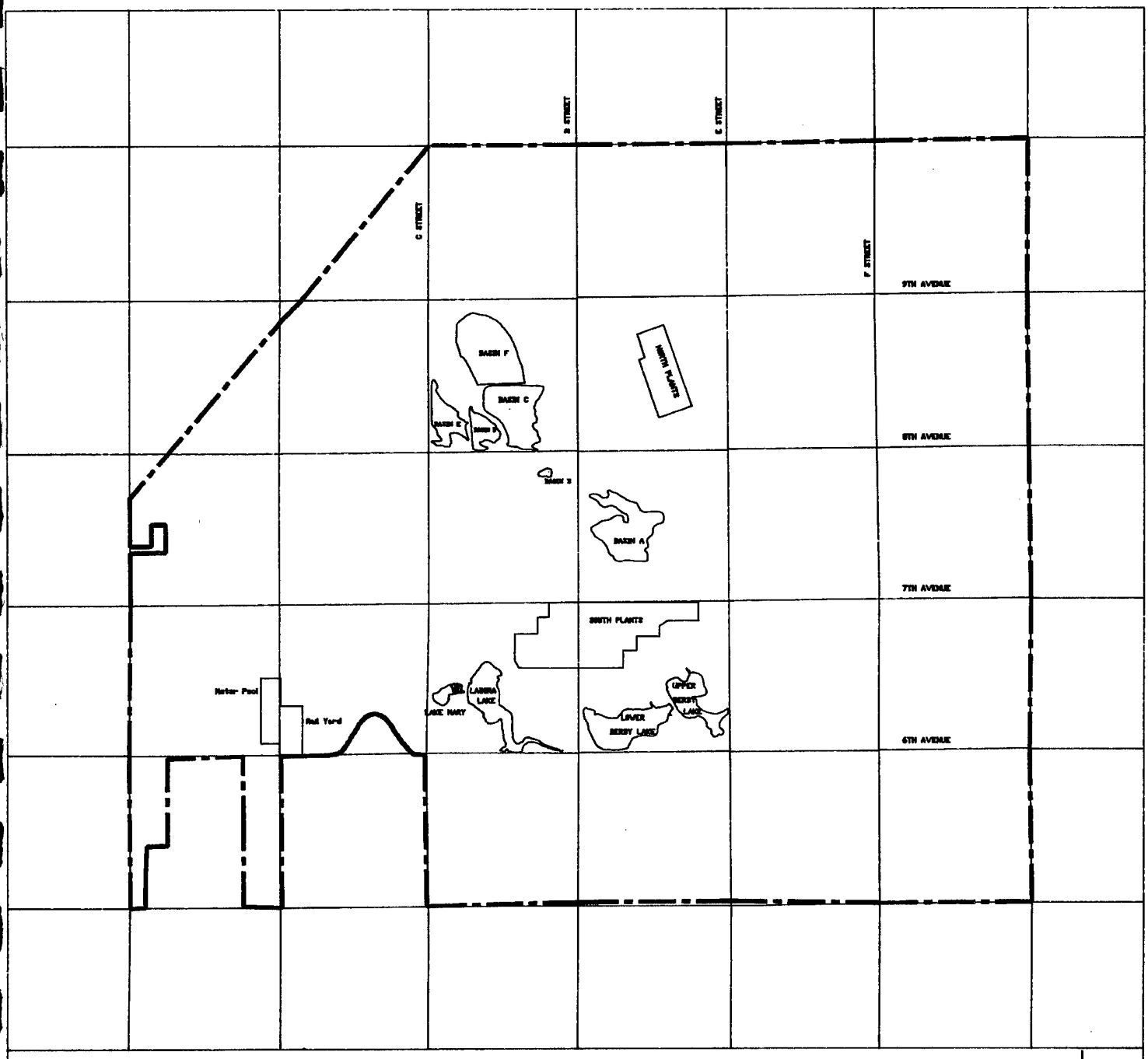
Ambient concentrations of the criteria pollutants, including sulfur dioxide, oxides of nitrogen, carbon monoxide, and ozone were monitored continuously at RMA during FY90. Lead was also analyzed from TSP samples. Generally, the air quality at the RMA monitoring location was cleaner than that at other sites in the Denver area. RMA data for criteria pollutants showed no violations of any applicable short-term or long-term standards. Episodes with relatively high concentrations at RMA were related to potential nearby sources under certain meteorological conditions. Several of these episodes were specifically related to typical Denver "brown cloud" conditions and have been identified in the FY90 report.




SOURCE: RMA, 1983. ESE, 1987

| | |
|---|---|
| Job No. : 22787E | **ROCKY MOUNTAIN ARSENAL LOCATION MAP** |
| Prepared by : T.R.H. | |
| Date : 10/20/92 | |

FIG. 1.1-1

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# Rocky Mountain Arsenal Reference Map

U.S. Program Manager — Rocky Mountain Arsenal

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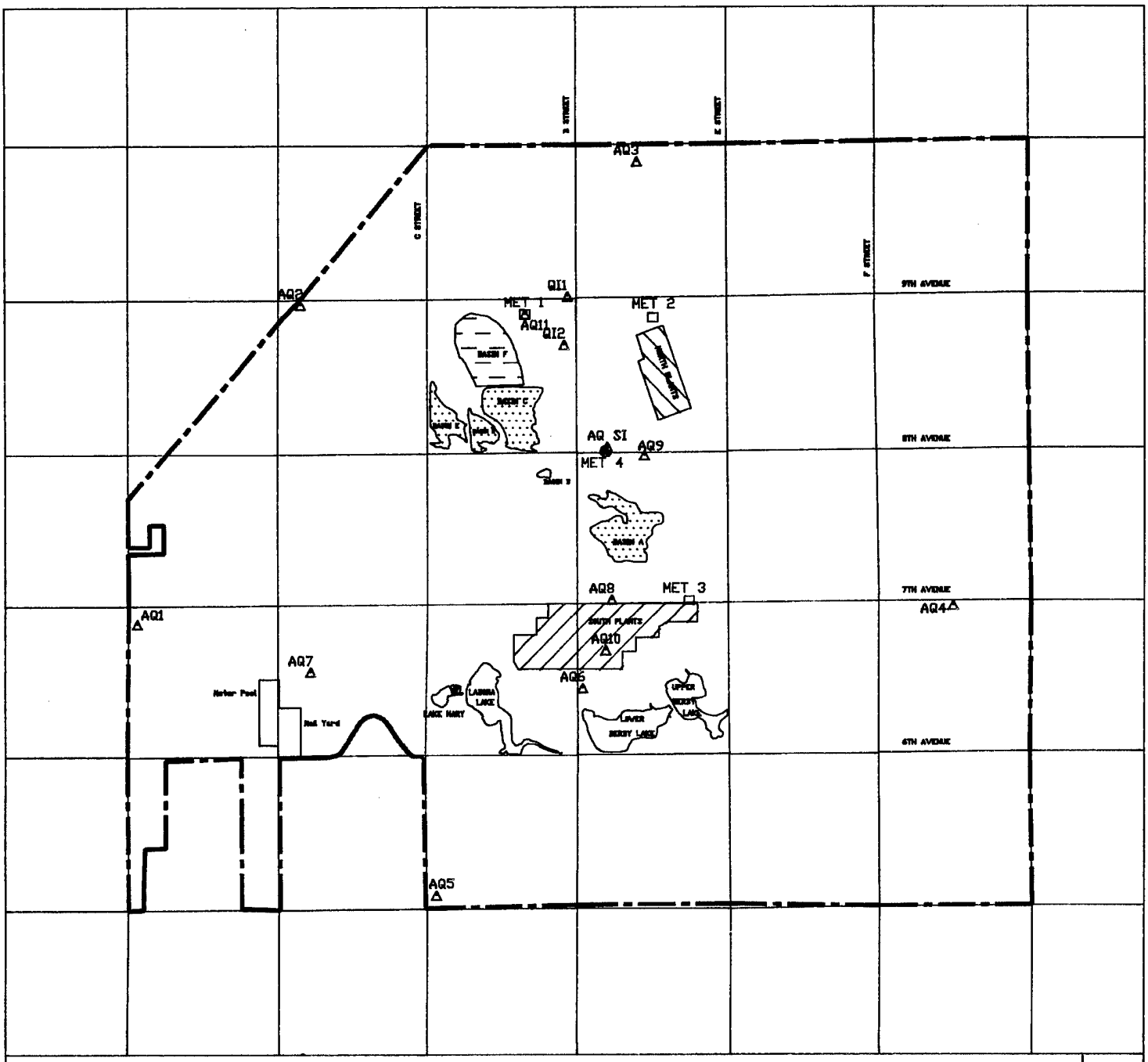
| DRWN BY : dwb | DATE : 5/5/92 | PROJECT NO: 22787E | FIG. NO : 1.1–2 |
| CHKD BY : . | DATE : . | | |




Legend

Potential Sources

Monitored Parameters

- TSP/PM-10
- TSP/PM-10, Asbestos, Volatile Organics, Semi-Volatile Organics
- TSP/PM-10, Asbestos
- TSP/PM-10, Metals, Arsenic, Mercury, Semi-Volatile Organics
- TSP/PM-10, Metals, Arsenic, Mercury, Semi-Volatile Organics, Volatile Organics (during FY88)
- Volatile Organics, Semi-Volatile Organics, Metals

- △ Air Quality Monitoring Station
- □ Meteorological Monitoring Station
- ⊙ Continuous Gases and Meteorological Monitoring Station, FY 89

N

5000 0 5000 10000
SCALE Feet

Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

# CMP Air Quality and Meteorological Monitoring Stations

U.S. Program Manager — Rocky Mountain Arsenal

| DRWN BY : dwb | DATE : 5/5/92 | PROJECT NO: 22787E | FIG. NO : 1.2-1 |
|---|---|---|---|
| CHKD BY : . | DATE : . | | |

# 2.0
# REGIONAL AND LOCAL AIR QUALITY AND METEOROLOGICAL CHARACTERISTICS

## 2.1 AIR QUALITY

The Denver metropolitan area, which includes RMA, has experienced chronic air quality problems in recent years. During stagnant and/or air inversion conditions, ozone and carbon monoxide concentrations sometimes create extremely poor air quality. This problem has generally been associated with motor vehicles, although air pollution also comes from a wide variety of industrial sources located in the Denver area. Major sources include power plants, oil refineries and transfer stations, chemical plants, cement plants and various agricultural operations. In addition to these sources,, substantial emissions occur as a result of wood burning. Considerable background air quality information for criteria pollutants influencing the RMA area is provided by the Colorado Department of Health (CDH 1984; 1985; 1986, 1987, 1988, 1989, 1990).

Also, a more detailed discussion of regional and local (Denver) air quality as well as potential metropolitan Denver area sources are provided in previous CMP Air Quality Data Assessment Reports (RLSA 1988, 1989, and 1990). Table 2.1-1 shows applicable Colorado and National Ambient Air Quality Standards (NAAQS) for criteria pollutants.

## 2.2 METEOROLOGY AND AIR QUALITY

The RMA area is generally classified as having a mid-latitude and semiarid climate, with hot summers, cold winters, and relatively light rainfall. Data were collected during FY91 both at RMA and at Stapleton International Airport (Stapleton Airport) adjacent to RMA. Because of the close proximity and relatively uniform topography between Stapleton Airport and RMA, the airport's longterm climatological and meteorological conditions are expected to be most representative of RMA long-term conditions and are referenced in the following discussion. However, RMA meteorological data collected at the four towers are assessed extensively in later sections of this report.

Mean maximum temperatures for the Denver area range from 43 degrees Fahrenheit (°F) in January to 88°F in July. The mean minimum temperatures are 16°F in January and 59°F in July. A summary of temperature patterns, presented by month and for the year based on a 30-year climatological period at Stapleton, is presented in Table 2.2-1.

Precipitation in the general region ranges from 12 to 16 in. per year, with approximately 80 percent falling between April and September. Snow and sleet usually occur from September to May, with the heaviest snowfall in March and possible trace accumulations as late as June. Thunderstorms occur frequently in the region and generally bring brief rain showers, gusty winds and frequent thunder and lightning. Occasionally these storms are accompanied by heavy showers, severe gusty winds, and hail. There are approximately 93 days per year with a cloud cover of 30 percent or less. A summary of monthly and annual precipitation and humidity, based on a 30-year climatological period from Stapleton, is presented in Table 2.2-2.

Wind directional frequencies reflect the drainage of the South Platte River Valley, which slopes gradually downward from south-southwest to north-northeast. Typically, surface winds in the area flow downslope (south to north) during the night, and upslope (north to south) during the daytime, resulting in a north-south bimodal distribution, as illustrated in the wind rose for the RMA vicinity (Figure 2.2- 1). Since the RMA area is on higher sloping terrain to the east of the South Platte River Valley, there is also a moderate easterly flow drainage component. Winds from all directions at moderate speeds will occur under varying synoptic conditions. The windy months are March and April, with gusts as high as 56 mph, generally from the north through the northwest. These windy months come immediately after the driest months of November through February, and therefore have the highest potential for dust storms. A summary of monthly and annual wind flow and atmospheric pressure patterns, again based on Stapleton data, is presented in Table 2.2-3. Table 2.2-4 summarizes cloud cover, visibility and precipitation type patterns in vicinity of RMA, also based on Stapleton data.

Pollutant dispersion is the result of varying meteorological influences. Early morning inversions over the Denver metropolitan area are common and occasionally persist throughout the day. These inversions prevent mixing of the atmospheric boundary layer

and causes accumulation of pollutants. Denver experiences stable atmospheric conditions nearly 60 percent of the year that favor high air pollution events. Most of these stable conditions are observed during the winter.

Another factor that contributes to high air pollution in Denver is the diurnal variation of upslope and downslope air flow along the Front Range. The metropolitan area is in the South Platte River basin, with decreasing elevation towards the north through northeast. As a result, cold, heavy air drains downslope at night and during the early morning hours. As the atmosphere warms during the afternoon, the flow reverses sharply, and much of the air that traversed the city earlier as clean air re-enters Denver as polluted air going upslope.

Because Denver is at a high altitude, the atmosphere is thin, allowing more ultraviolet radiation to interact with airborne contaminants. Chemical reactions initiated by photochemical processes increase Denver's smog problem, particularly the ozone portion of smog. A more detailed evaluation relating meteorological conditions at RMA to the dispersion of atmospheric pollutants and potential contaminants will be discussed in subsequent sections of this report.

## TABLE 2.1-1

## COLORADO AND NATIONAL AMBIENT AIR QUALITY STANDARDS

| Pollutant | Averaging Time | Concentration |
|---|---|---|
| Carbon Monoxide (CO) | | |
| Primary | 1-Hour* | 35 ppm (40 $mg/m^3$) |
| Primary | 8-Hour* | 9 ppm (10 $mg/m^3$) |
| Ozone ($O_3$) | | |
| Primary | 1-Hour** | 0.12 ppm (235 $\mu g/m^3$) |
| Nitrogen Dioxide ($NO_2$) | | |
| Primary | Annual Arithmetic Mean | 0.053 ppm (100 $\mu g/m^3$) |
| Secondary | Annual Arithmetic Mean | 0.053 ppm (100 $\mu g/m^3$) |
| Sulfur Dioxide ($SO_2$) | | |
| Primary | Annual Arithmetic Mean | 0.03 ppm (80 $\mu g/m^3$) |
| Primary | 24-Hour* | 0.14 ppm (365 $\mu g/m^3$) |
| Secondary | 3-Hour* | 0.5 ppm (1300 $\mu g/m^3$) |
| Particulates (TSP)*** | | |
| Primary | Annual Geometric Mean | 75 $\mu g/m^3$ |
| Secondary | Annual Geometric Mean | 60 $\mu g/m^3$ |
| Primary | 24-Hour* | 260 $\mu g/m^3$ |
| Secondary | 24-Hour* | 150 $\mu g/m^3$ |
| Particulates (PM-10) | | |
| Primary | Annual Arithmetic Mean | 50 $\mu g/m^3$ |
| Primary | 24-Hour | 150 $\mu g/m^3$ |
| Lead (Pb) | | |
| Primary | Month/Quarter**** | 1.5 $\mu g/m^3$ |

Source: Colorado Department of Health, 1989

* Not to be exceeded more than once per year.

** Statistically estimated number of days with exceedances averaged over a three year period, is not to be more than 1.0 per year.

*** TSP standards have been superseded by the recently promulgated PM-10 standards; these values are presented for comparison purposes only.

**** The federal standard is averaged over a 3-month (calendar quarter) period; the Colorado standard is averaged over a 1-month period.

ppm Parts of pollutant per million parts of air.

$\mu g/m^3$ Micrograms of pollutant per cubic meter of air at 760 mm Hg and 25°C.

$mg/m^3$ Milligrams per cubic meter.

Primary Primary standard intended to protect public health.

Secondary Secondary standard intended to protect public welfare.

## TABLE 2.2-1

## SUMMARY OF TEMPERATURE DATA IN THE RMA VICINITY

| | Temperature | | | | | | | Mean Number of Days | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Normal[1] | | | Extreme[2] | | | | Max. | | Min. | |
| Month | Daily Maximum | Daily Minimum | Monthly | Record Highest | Year | Record Lowest | Year | 90°F & above | 32°F & below | 32°F & below | 0°F & below |
| | | | | 49[3] | | 49[3] | | 23[3] | 23[3] | 23[3] | 2 3[3] |
| January | 43.1 | 15.9 | 29.5 | 73 | 1982 | -25 | 1963 | 0 | 7 | 30 | 4 |
| February | 46.9 | 20.2 | 33.6 | 76 | 1963 | -30 | 1936 | 0 | 4 | 26 | 2 |
| March | 51.2 | 24.7 | 38.0 | 84 | 1971 | -11 | 1943 | 0 | 3 | 25 | 1 |
| April | 61.0 | 33.7 | 47.4 | 85 | 1960 | -2 | 1975 | 0 | - | 12 | - |
| May | 70.7 | 43.6 | 57.2 | 96 | 1942 | 22 | 1954 | - | 0 | 2 | 0 |
| June | 81.6 | 52.4 | 67.0 | 104 | 1936 | 30 | 1951 | 6 | 0 | 0 | 0 |
| July | 88.0 | 58.7 | 73.3 | 104 | 1939 | 43 | 1972 | 15 | 0 | 0 | 0 |
| August | 85.8 | 57.0 | 71.4 | 101 | 1938 | 41 | 1964 | 9 | 0 | 0 | 0 |
| September | 77.5 | 47.7 | 62.6 | 97 | 1960 | 20 | 1971 | 2 | 0 | 1 | 0 |
| October | 66.8 | 36.9 | 51.9 | 88 | 1947 | 3 | 1969 | 0 | - | 8 | - |
| November | 52.4 | 25.1 | 38.7 | 79 | 1941 | -8 | 1950 | 0 | 2 | 24 | - |
| December | 46.1 | 18.9 | 32.6 | 75 | 1980 | -21 | 1983 | 0 | 5 | 29 | 3 |
| Annual | 64.3 | 36.2 | 50.3 | 104 | July 1939 | -30 | Feb. 1936 | 33 | 22 | 158 | 9 |

Source: Hunter/ESE, Air Remedial Investigation, Final Report, Version 3.1, August, 1988.

1 Normal - based on record for the 1951-1980 period.

2 Extreme - length of record may be for other than complete or consecutive data years. Date is the most recent in cases of multiple occurrences.

3 Length of record, years, based on January data.

# TABLE 2.2-2

## SUMMARY OF PRECIPITATION AND HUMIDITY DATA IN THE RMA VICINITY

| | Precipitation (inches) | | | | | | | | | | | Relative Humidity % | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Water Equivalent | | | | | | Snow, Ice pellets | | | | | | | |
| Month | Normal[1] | Max.[2] Monthly | Year | Min. Monthly | Year | Max. in 24 hrs. | Year | Max. Monthly | Year | Max in 24 hrs. | Year | 0.5 hr | 11 hr (local time) | 17 hr (local time) | 23 hr |
| | | 49[3] | | 49[3] | | 49[3] | | 49[3] | | 49[3] | | 23[3] | 23[3] | 23[3] | 23[3] |
| January | 0.51 | 1.44 | 1948 | 0.01 | 1952 | 1.02 | 1962 | 23.7 | 1948 | 12.4 | 1962 | 63 | 46 | 49 | 63 |
| February | 0.69 | 1.66 | 1960 | 0.01 | 1970 | 1.01 | 1953 | 18.3 | 1960 | 9.5 | 1953 | 66 | 43 | 42 | 34 |
| March | 1.21 | 4.56 | 1983 | 0.13 | 1945 | 2.79 | 1983 | 30.5 | 1983 | 18.0 | 1983 | 67 | 42 | 41 | 34 |
| April | 1.81 | 4.17 | 1942 | 0.03 | 1963 | 3.25 | 1967 | 28.3 | 1935 | 17.3 | 1957 | 67 | 37 | 34 | 58 |
| May | 2.47 | 7.31 | 1957 | 0.06 | 1974 | 3.55 | 1973 | 13.6 | 1950 | 10.7 | 1950 | 70 | 40 | 38 | 61 |
| June | 1.58 | 4.69 | 1967 | 0.09 | 1960 | 3.16 | 1970 | 0.3 | 1951 | 0.3 | 1951 | 70 | 37 | 35 | 59 |
| July | 1.93 | 6.41 | 1965 | 0.17 | 1939 | 2.42 | 1965 | 0.0 | | 0.0 | | 68 | 35 | 34 | 56 |
| August | 1.53 | 5.85 | 1979 | 0.06 | 1960 | 3.43 | 1951 | 0.0 | | 0.0 | | 69 | 37 | 35 | 58 |
| September | 1.23 | 4.67 | 1961 | T[4] | 1944 | 2.44 | 1936 | 21.3 | 1936 | 19.4 | 1936 | 68 | 37 | 34 | 59 |
| October | 0.98 | 4.17 | 1969 | 0.05 | 1962 | 1.71 | 1947 | 31.2 | 1969 | 12.4 | 1969 | 64 | 36 | 35 | 58 |
| November | 0.82 | 2.97 | 1946 | 0.01 | 1949 | 1.29 | 1975 | 39.1 | 1946 | 15.9 | 1983 | 68 | 44 | 49 | 65 |
| December | 0.55 | 2.84 | 1973 | 0.03 | 1977 | 2.00 | 1982 | 30.8 | 1973 | 23.6 | 1982 | 64 | 45 | 51 | 63 |
| Annual | 15.31 | 7.31 | May 1957 | T[4] | Sept. 1944 | 3.55 | May 1973 | 39.1 | Nov 1946 | 23.6 | Dec 1982 | 67 | 40 | 40 | 60 |

Source: Hunter/ESE, Air Remedial Investigation, Final Report, Version 3.1, August, 1988

1 Normal - based on record for the 1951-1980 period.
2 Maximum - length of record may be for other than complete or consecutive date years. Date is the most recent in cases of multiple occurrences.
3 Length of record, years, through the last year recorded unless other wise noted, based on January date.
4 T = Trace; blank entries denote missing or unreported data.

Note: Normal cooling degree data published in the 1982 Annual were for the 1951-1980 period.

## TABLE 2.2-3

## SUMMARY OF WIND AND PRESSURE DATA IN THE RMA VICINITY

| | Wind | | | | | Average Station |
|---|---|---|---|---|---|---|
| | | Thru 1968 | Fastest mile[1] | | | Pressure mb |
| Month | Mean Speed (mph)[2] | Prevailing Direction | Speed (mph) | Direction [3] | Year | Elevation 5,332 ft msl |
| | 35[4] | 15[4] | 31[4] | 31[4] | | 11[4] |
| January | 3.3 | S | 53 | N | 1976 | 833.9 |
| February | 9.1 | S | 49 | NW | 1953 | 834.2 |
| March | 9.9 | S | 53 | NW | 1952 | 831.1 |
| April | 10.2 | S | 56 | NW | 1960 | 833.2 |
| May | 9.4 | S | 54 | SE | 1978 | 833.9 |
| June | 9.0 | S | 47 | S | 1956 | 836.2 |
| July | 8.4 | S | 56 | SW | 1965 | 838.9 |
| August | 8.1 | S | 42 | N | 1978 | 838.9 |
| September | 8.1 | S | 47 | NW | 1955 | 838.6 |
| October | 8.0 | S | 45 | NW | 1958 | 837.7 |
| November | 8.5 | S | 48 | W | 1962 | 835.5 |
| December | 8.8 | S | 51 | NE | 1953 | 834.5 |
| Annual | 8.8 | S | 56 | SW | July 1965 | 835.6 |

Source: Hunter/ESE, Air Remedial investigation, Final Report, Version 3.1, August, 1988.

1 Fastest Mile Wind - speed is fastest observed in 1-minute value when direction is in tens of degrees. Fastest mile winds are through August 1981.

2 Means and extremes above are from existing and comparable exposures. area extremes have been exceeded at other sites in the locality as follows: wind - fastest mile = W in May 1933.

3 Wind Direction - numerals indicate tens of degrees clockwise from true north. 00 indicates calm.

4 Length of record, years, through the current year unless otherwise noted, based on January data.

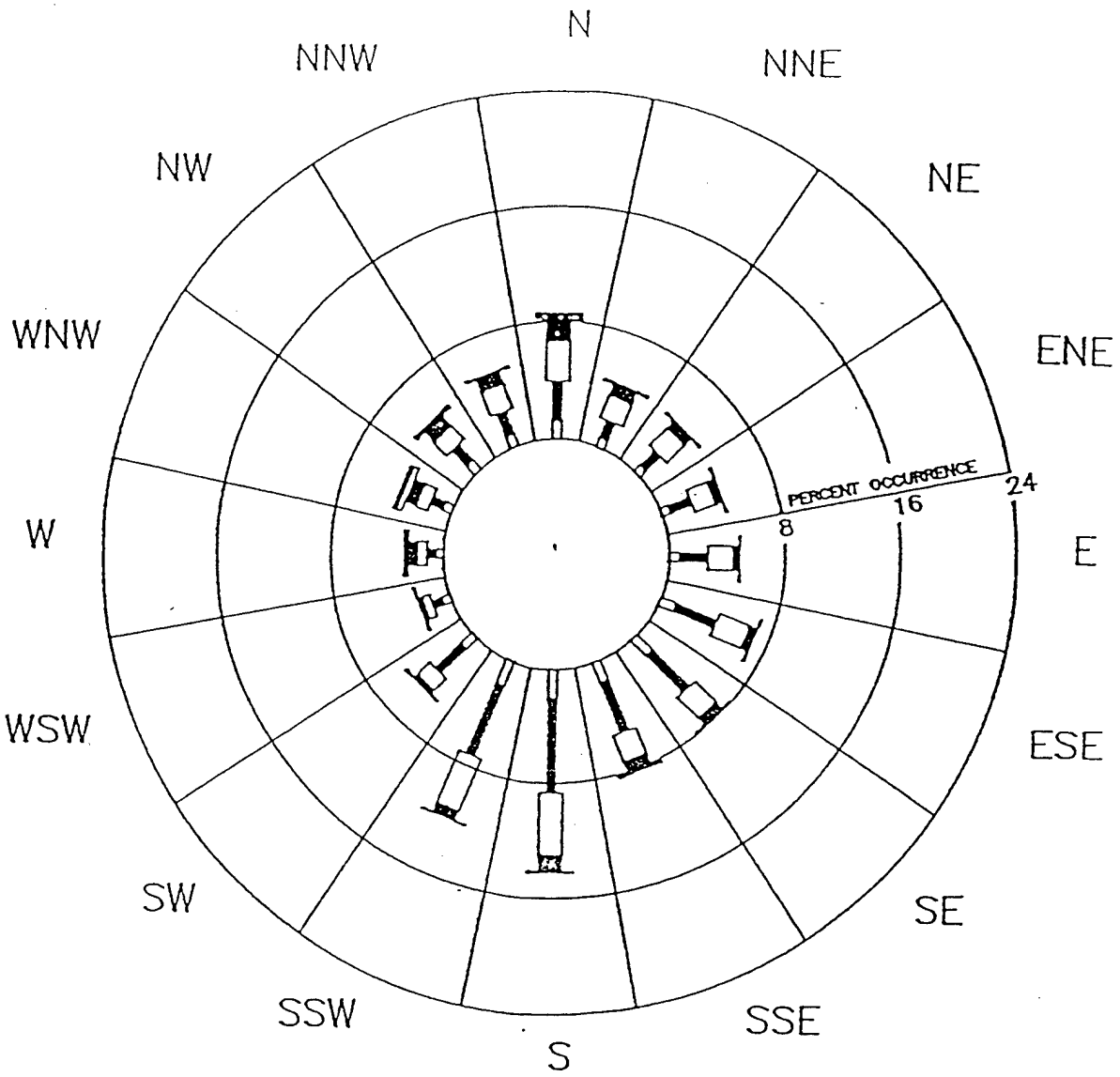
## TABLE 2.2-4

## SUMMARY OF METEOROLOGICAL DATA IN THE RMA VICINITY

| Month | Percent of Possible Sunshine | Mean Sky Cover, Tenths, Sunrise to Sunset | Mean Number of Days: Sunrise to Sunset | | | Precipitation 0.01 inch or More | Snow, Ice Pellets 1.0 inch or More | Thunderstorms | Heavy Fog, Visibility 1/4 mile or Less |
|---|---|---|---|---|---|---|---|---|---|
| | | | Clear | Partly Cloudy | Cloudy | | | | |
| | 34* | 35* | 49* | 49* | 49* | 49* | 49* | 43* | 43* |
| January | 42 | 5.6 | 10 | 9 | 12 | 6 | 2 | 0 | 1 |
| February | 71 | 5.9 | 8 | 8 | 12 | 6 | 2 | -- | 2 |
| March | 70 | 6.1 | 8 | 10 | 13 | 9 | 4 | -- | 1 |
| April | 68 | 6.0 | 7 | 11 | 12 | 9 | 3 | 1 | 1 |
| May | 64 | 6.3 | 6 | 12 | 13 | 11 | --** | 6 | 1 |
| June | 71 | 6.0 | 10 | 12 | 8 | 9 | 0 | 10 | -- |
| July | 72 | 4.9 | 9 | 16 | 6 | 9 | 0 | 11 | -- |
| August | 72 | 4.9 | 10 | 14 | 7 | 9 | 0 | 8 | 1 |
| September | 75 | 4.3 | 13 | 10 | 7 | 6 | -- | 3 | 1 |
| October | 73 | 4.5 | 13 | 10 | 8 | 5 | 1 | 1 | 1 |
| November | 65 | 5.4 | 10 | 10 | 10 | 5 | 2 | -- | 1 |
| December | 67 | 5.4 | 11 | 9 | 11 | 5 | 2 | 0 | 1 |
| Annual | 70 | 5.4 | 115 | 131 | 119 | 88 | 18 | 41 | 10 |

Source: Hunter/ESE, Air Remedial Investigation, Final Report, Version 3.1, August, 1988.

* Length of record, years, based on January data.
** Less than 0.5 inch.




| | |
|---|---|
| Job No. : 22787E | **STAPLETON AIRPORT WIND DIRECTION ROSE, 1982 - 1986** |
| Prepared by : T.R.H. | |
| Date : 10/20/92 | |

FIG. 2.2-1

# 3.0
# PROGRAM STRATEGY AND METHODOLOGY

## 3.1 GENERAL BACKGROUND

The procedures for air sample collection and analysis are described in detail in the CMP Final Technical Plan. The methods for meteorological data collection are also contained in the Technical Plan. This section provides a brief overview of the sampling and analysis program with emphasis on field activities accomplished during the CMP FY91 Program. The Technical Plan provides a flexible vehicle for upgrading CMP monitoring requirements and techniques as experience is gained and as remedial programs continue. For example, past modifications included the addition of continuous gaseous monitoring ($O_3$, CO, $SO_2$, and $NO_x$) and the incorporation of a four-tower meteorological network into the CMP. During FY91, all IRA-F monitoring sites were included in the CAQMMP, as well as cap and vent monitoring off the Basin F waste pile, tank farm, and pond vents. During FY91, the CMP also conducted air monitoring of off-gases from the air stripper located within the Basin A Neck ground-water intercept facility, and monitoring of TSP, PM-10, metals, VOC, and OCP upwind and downwind, based on prevailing wind flow, of the proposed quench incinerator site. These changes significantly increased CMP VOC and OCP monitoring and also substantially increased TSP, PM-10, and metals monitoring.

During the CMP FY91 program, the following parameters were sampled:

1. Air Quality

   - Total suspended particulates (TSP)
   - Respirable particulates (PM-10)
   - Asbestos
   - Volatile organic compounds (VOC)
   - Organochlorine pesticides (OCP)
   - Total organics (using HNu and OVA monitors)
   - Metals

- Arsenic (As)
- Mercury (Hg)
- Sulfur dioxide ($SO_2$)
- Carbon monoxide (CO)
- Ozone ($O_3$)
- Nitrogen dioxide ($NO_2$)
- Nitric oxide (NO)
- Nitrogen oxides ($NO_x$)
- Visibility characterizations (see Section 6.0)

2. Meteorology

- Wind speed and direction
- Standard deviation of wind direction (sigma theta)
- Temperature
- Barometric pressure
- Precipitation
- Humidity
- Solar radiation

## 3.2 CMP AIR QUALITY MONITORING PROGRAM

Sample location and equipment, sampling frequency and method, and justification for selecting sample locations and parameters monitored are presented in this section. Specific sample handling procedures are discussed in a separate document, "Field Procedures Manual for the Comprehensive Monitoring Program (RLSA, 1988)." Procedures to develop the database were in accordance with PMRMA requirements for sample collection, sample preservation, sample shipment, sample analysis, and chain-of-custody.

### 3.2.1 Siting Criteria

Air samples were collected from permanent and mobile air quality stations on RMA. Figure 3.2-1 shows the locations of the permanent stations on the perimeter of RMA,

near Basins A and F, the South Plants area, the North Plants complex, and the rail classification yard. Stations incorporated into the CMP from the IRA-F program are designated as "FC". Those stations established to monitor the proposed quench incinerator facility are designated as "QI". Portable air quality stations were also used; their locations were determined from high event conditions and remedial monitoring activities, as described in Sections 3.2.2.2 and 3.2.3.2. All stations were documented or surveyed as described in Table 3.2-1.

Locations of air quality stations were based on the following criteria:

- Proximity to a suspected contaminant source or RMA boundaries;
- Predominant wind speed and direction;
- Topographical features and obstructions; and
- Continuity with previous monitoring programs to maintain data integrity.

These criteria are discussed in detail below.

#### 3.2.1.1 Proximity to Sources or Boundaries

All air quality stations were located either near a potential contaminant source or along the RMA boundary. Samplers were located near suspected contaminant sources and were positioned to collect airborne contamination originating from the source areas. Samplers located at the perimeter of RMA were established to monitor airborne contaminants crossing the RMA boundaries. These locations focused on-site sources; however off-site sources also contributed to samples taken at these locations.

#### 3.2.1.2 Wind Speed/Direction

Predominant wind speeds and directions were considered in choosing the locations of air quality stations. Figure 2.2-1, cited previously, indicates that during a recent 5-year period (1982 to 1986), the prevailing winds were from the south and south-southwest (representing downslope nighttime drainage). The next most frequent wind direction was from the north (representing typical daytime upslope heating effects). The strongest wind speeds were most frequently observed from the west, resulting from downslope

wind off the foothills. These wind conditions have been substantiated by CMP FY88 through FY91 meteorological monitoring. While typical wind data are represented on the wind rose, highly variable conditions can occur on any given day.

### 3.2.1.3 Topographical Features and Obstructions

All air quality locations were in accordance with siting criteria given in EPA's document "Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD) for TSP Sampling" (EPA, 1987). Because all permanent stations maintained TSP high-volume air samplers, the following guidelines were followed:

- Stations were at least 20 meters from trees;
- Stations were placed away from buildings or other obstacles, such that the distance between an obstacle and sampler was equal to at least twice the height that the obstacle protruded above the sampler;
- At stations where there were multiple or collocated samplers, at least 2 meters separated the samplers;
- The stations were, to the extent possible, at least 25 meters from roadways;
- The sample inlet was approximately 2 meters above the ground;
- To assess sampling precision, collocated TSP and PM-10 samplers were placed at site AQ5; VOC and OCP collocated samples were at FC1;
- All the stations were placed at representative terrain locations.

### 3.2.1.4 Continuity With Previous Monitoring Programs

The CMP continues a data collection program initiated under the Remedial Investigation. Twelve permanent sample locations were maintained under this program.

Sampling results were reported in the Air Remedial Investigation Final Report (ESE, 1988). Critical to the CMP is maintaining the integrity of the data for comparison and assessment purposes. As such, the CMP FY91 permanent monitoring sites were the same locations as those for FY90. These site locations were essentially the same as for CMP FY88 and FY89. In order to maintain continuity in assessment of the remedial program, the CMP "FC" sites were maintained at the same locations as those established under the Basin F and IRA-F monitoring programs.

### 3.2.2 The CMP Air Quality Monitoring Network Locations

#### 3.2.2.1 Permanent Stations

Figure 3.2-1 shows the locations of 11 permanent air quality stations, the FY91 location of mobile station AQ10, and one collocated fixed station (at AQ5). TSP was monitored at all active stations, PM-10 at nine stations, and asbestos at four stations, as described below. VOC, OCP and metals were monitored with both fixed and mobile samplers that were also positioned to collect high event levels of contaminants. VOCs were monitored routinely at 10 fixed site locations, while OCPs and metals were monitored at 11 fixed sites. In addition, during worst-case monitoring scenarios, the selected sampling locations for organics and metals were established at portable stations according to meteorological conditions or were placed at the permanent stations. The rationale for locating each permanent and portable station is described in the Technical Plan. There are no changes to these descriptions.

#### 3.2.2.2 Portable Air Quality Monitoring Stations

As noted, VOC, OCP and metals were sampled at the permanent air quality monitoring stations and at portable stations on high event days. Mercury was sampled only at portable sites and only on high event days. In the past, the portable stations were employed near potential contaminant sources in areas including Basin F, the South Plants, the Hydrazine Plant, Basin A, and Basin A Neck. For example, a high event day may have had winds from the west. Using portable stations, samples were collected downwind directly east of the potential contaminant source; upwind stations were also sampled at these times for comparison to downwind samples. On several occasions, four

or more mobile stations were placed surrounding the potential source. During FY91, four VOC and OCP mobile, samplers were positioned on separate occasions in the Basin F area, the quench incinerator area, and the South Plants subdrain area to monitor high event conditions. Metals and mercury high event conditions were monitored at these same locations in addition to the South Plants and Basin A areas.

The FY91 program also called for one portable station to monitor TSP (AQ10). This station was to be placed at areas of special interest, such as locations that were influenced by remedial activity. During the CMP FY89 program, AQ10 operated at the northern perimeter of Basin F in the direction of the prevailing wind flow off the basin from October 1, 1989, to April 19, 1990. AQ10 (designated AQ10A) was then located in the northeast corner of Section 35 (downwind from Basin A Neck construction activities) from April 20 to September 4, 1990, and was moved on September 5, 1990, (designated AQ10B) to the northwest quarter of Section 1 (downwind from South Plants subdrain operations) where it remained through FY91.

The portable stations provided flexibility to react to changing events as remedial activities proceeded at RMA. All activities at portable stations were documented to indicate location, parameters measured, date, time in operation, and frequency of use. When a portable station was employed, EPA guidelines for positioning air quality monitoring stations were followed where appropriate (USEPA, 1987). Portable propane generators were available as the power supply for the portable monitoring stations when line power was not used for AC-power samplers.

### 3.2.3 Air Quality Monitoring Strategies

#### 3.2.3.1 Baseline Monitoring

Several monitoring strategies were developed to establish a broad baseline of air quality conditions in the RMA vicinity. The first program element was the collection of baseline data for TSP, PM-10, metals, arsenic, mercury, VOC, OCP and asbestos for routine sampling periods as described in the Technical Plan. This program is a continuation of monitoring guidelines initiated under the Remedial Investigation program in 1986-1987 and later maintained under the CMP. Table 3.2-2 lists the parameters and strategies for

the FY91 air monitoring program. The schedule for 6-day sampling is shown in Figure 3.2-2. This schedule coincides with the National and Colorado Department of Health ambient air quality sampling programs.

Detailed monitoring methods are provided in Section 3.2.4, as well as in Appendix A of the Field Procedures Manual (RLSA, 1988). Laboratory analytical procedures are described in Section 3.6.

### 3.2.3.2 Worst-Case Assessment

The second element was high event monitoring. High event monitoring was conducted in the vicinity of the site boundaries and suspected contaminant source areas under the Remedial Investigation Program and was continued under the CMP. Because of the low background levels often encountered in these areas under normal weather conditions, sampling for organic compounds and metals was directed toward high event days or worst-case situations. Various strategies were developed to optimize the high event collection program; Table 3.2-3 lists the sampling strategies for high event air quality monitoring as established in the Technical Plan.

During the CMP FY88 and FY89 programs, high event monitoring was principally conducted in the vicinity of Basin F in order to assess potential worst-case conditions while remediation activity occurred in these areas and to assess remedial progress after cleanup was completed. High event monitoring was also conducted at the Arsenal boundaries, South Plants, Basin A, Basin A Neck, and the Hydrazine Plant. This approach continued in FY91; however, the focus of high event monitoring was expanded to new areas of construction or remedial effort, including the quench incinerator and the South Plants subdrain operations.

### 3.2.3.3 Remedial Assessment

A third element in the CMP includes strategies for remedial actions monitoring support. Parameters to be monitored include those described for the general ambient monitoring programs, plus special contaminants associated with unique remediation concerns.

During FY90, CMP monitoring was conducted at Basin A Neck to supplement monitoring in the vicinity of this operation. Monitoring was also initiated at the South Plants subdrainage area to complement remedial efforts undertaken by Harding Lawson Associates. During FY91, the IRA-F Basin F monitoring program was incorporated into the CMP in order to continue post-remedial assessment of this important remedial activity. Also during FY91, two new permanent stations, QI1 and QI2, were established to monitor air quality in the vicinity of the proposed quench incinerator. Monitoring was also performed of off-gases from the air stripper located at the Basin A Neck ground-water intercept facility.

Remedial activities have a significant impact on CMP monitoring results, making it essential to evaluate all CMP data in relation to the remedial program. For example, differences between the 1986-1987 Remedial Investigation Program results when no major remedial activity was in progress, when Basin F cleanup activity was in full progress, and when Basin F cleanup activity was concluded are quite evident and provide a very meaningful assessment of remedial progress.

#### 3.2.3.4 Gaseous Pollutant Assessment

A fourth element in the CMP is the continuous monitoring of gaseous pollutants including carbon monoxide, sulfur dioxide, ozone and nitrogen dioxide. This program is required to establish a baseline of gaseous pollutants to support possible future RMA activities and to assess the status of non-attainment pollutants and/or those of special concern in the Denver metropolitan area. This program has been operating continuously since May 1989, except for a gap in data collection from October 1, 1990, to January 24, 1991, when the CMP was temporarily suspended. Results of the continuous gaseous monitoring program are provided in Section 5.0 and Appendix H.

### 3.2.4 Air Quality Monitoring Methods

Sampling methods for TSP, PM-10 and asbestos were standard reference methods used by the EPA or the National Institute of Occupational Safety and Health (NIOSH, 1984). Certifications for these methods were not necessary. Analytical methods for volatile organics, organochlorine pesticides, metals, arsenic and mercury were reviewed and

certified by PMRMA. Details of sampler design and operation as well as reference methods are provided in the Technical Plan.

The Field Procedures Manual contains specific operation, calibration and maintenance procedures for the TSP and PM-10 samplers. The following sections briefly describe the procedures followed for sample collection. All sampling times are 24 hours with the exception of several high events documented in the text.

### 3.2.4.1 Total Suspended Particulates (TSP)

Sample collection and analytical procedures for TSP followed the EPA reference method as described in "Reference Method for the Determination of Suspended Particulate Matter in the Atmosphere" (CFR Title 40, Appendix B, 1985). As presented in the Analytical Methods Manual, the detection range for this method is 2 to 750-micrograms per standardized cubic meter of air ($\mu g/std\ m^3$). During FY91, Whatman QM-A quartz fiber filters were used for TSP collection.

The high-volume (Hi-Vol) samplers were General Metal Works Model GMWL-2000H. Air flow was controlled with electronic mass flow controllers. The target flow rate was 40 standard cubic feet per minute (scfm). An installed pressure transducer/recorder indicated the air flow to provide a permanent record of the flow rate for each sample. An adjustable timer was built into the samplers to start and stop the samplers at the required times. Calibrations were conducted quarterly, or more often, if required.

### 3.2.4.2 Particulate Matter Less Than 10 Microns (PM-10)

Sample collection and analytical procedures followed standard procedures similar to TSP monitoring. A Whatman, QM-A, quartz filter was used for collection (CFR Title 40, Appendix J, 1987). A General Metal Works size-selective Accu-Vol IP-10 Sampler with Model 1200 Inlet was employed. Particles of 10 $\mu m$ or less in size pass through the impaction chamber and are collected on the filter. The target flow rate was 40 actual cubic feet per minute (acfm).

Calibration for PM-10 samplers followed the manufacturer's written protocols; seasonal average temperature and pressure data were used to establish actual (volumetric) flow control set points per manufacturer's calibration recommendations. The PM-10 samplers and associated manufacturer's operation manuals are both included in EPA Reference/ Equivalency designation.

### 3.2.4.3 Asbestos

Sample collection and analytical procedures followed the NIOSH Method 7400, revised March 1, 1987, presented in Appendix B of the Procedures Manual (NIOSH, 1987). Sample volume, microscope count field area, and background airborne particulates define the usable range of the method. The minimum total fiber count in 100 microscope fields considered adequate for reliable quantification is 10 fibers.

### 3.2.4.4 Volatile Organic Compounds

The collection and analytical methods for VOCs were certified by PMRMA and incorporated modifications to guidelines given in EPA Method TO-1, "Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air" (USEPA, 1984). The TO-1 method involves the use of a sorbent to trap organic compounds that have a wide range of volatility. Method TO-1 employs Tenax GC adsorbent (poly 2,6-diphenyl phenylene oxide) to trap organic species having a boiling point range of 80 degrees Celsius (°C) to 200°C. All collected samples include three sorbent sections in two tubes, which consist of a primary Tenax tube, and a Tenax section followed by a charcoal section in the second tube. The target flow rate was 200 standard cubic centimeters per minute (sccm). The PMRMA certification method used for VOC analyses was CM04.

### 3.2.4.5 ICP Metals and Arsenic

Collection and analytical methods for metals and arsenic were certified by PMRMA. The collection methodology for metals followed the EPA method for lead determination, "Reference Method for the Determination of Lead in Suspended Particulate Matter Collected from Ambient Air" (CFR Title 40, Appendix G, 1978, 1979). The analytical

methodology for determining arsenic followed EPA Method 206.2, while determinations for the remaining metals were adapted from NIOSH Method 7300 (NIOSH, 1984) for elements in air using inductively coupled argon plasma (ICAP) emission spectrometry. These methods are contained in Appendix B of the CMP Procedures Manual (RLSA, 1988). Samples were collected in a standard Hi-Vol sampling apparatus used for TSP sampling. Chemical analyses were performed on a portion of the TSP filters after the gravimetric analyses were completed. Methods followed EPA or NIOSH procedures and were certified via the PMRMA quality assurance program. The certification method used for metals and mercury during this sampling period was AS-01 and AB-01, respectively.

#### 3.2.4.6 Organochlorine Pesticides (OCP)

The methodology for OCP (formerly OTSP) was adapted from EPA Method TO-4 (Analytical Methods Manual) and method 608, "EPA Test Method for Organochlorine Pesticides and PCBs" (USEPA, 1984). The filter and PUF (polyurethane foam) section are sublet extracted with methylene chloride. The extract is exchanged to hexane. The extract is then concentrated using a KD apparatus, and a GC/ECD is used to determine aldrin, dieldrin, endrin, isodrin, PPDDT, PPDDE, and chlordane weight. The PUF media used for this method are preextracted in a sublet apparatus before use. Sample blanks are analyzed to monitor background contamination.

OCP samples were collected using General Metal Works PS-1 samplers, identical to those sampling devices used previously in SVOC sample collection. In this method, ambient air is drawn through a quartz fiber filter followed by a PUF sorbent section. The target aeration flow rate was 200 standard liters per minute (slpm).

#### 3.2.4.7 Mercury

Mercury sampling was not performed during CMP FY88, but began during FY89 on October 26, 1988. Hydrar tubes manufactured by SKC, Inc. were used for sampling mercury and the analysis was performed according to the Rathje and Marcero method (AIHA, 1976). The hydrar tubes contained 500 mg of hopcalite, a treated charcoal, and

were digested using acid. The digestate was analyzed by cold vapor atomic absorption spectroscopy (CVAAS).

## 3.3 THE IRA-F AIR MONITORING PROGRAM

### 3.3.1 Background

Ambient air quality monitoring was carried out by the contractor performing the Basin F Interim Remediation Action from March 1988 to May 1989. The main purpose of this monitoring was to characterize atmospheric concentrations in the perimeter zone around Basin F, to provide data to characterize potential impacts off-site, and to determine impacts from nontarget compounds. Since the air quality data collected are an important ingredient of the Basin F post-remedial assessment provided in this report, a brief discussion of the remediation monitoring program follows. Target compounds virtually identical to the CMP target list were monitored, including VOC, OCP, total suspended particulates, metals, mercury, and ammonia. Sample collection was targeted for a 24-hour period.

To provide a conservative estimate of off-site migration, and to generate data that were likely to provide a source characterization, the sampling methodology called for specific monitoring schedules at specific sites. The locations of these sites and their designator codes are shown in Figure 3.3- 1. Sites BF1, BF2, BF3, and BF4 were at the perimeter of the Exclusion Zone, and Sites BF5, BF6, and BF7 were the off-site (beyond the Exclusion Zone) locations.

### 3.3.2 IRA-F Sampling Strategy

The IRA-F Air Quality Program was initiated during May 1989 as a follow-up sampling program for air quality near the Basin F site. The program was continued through FY90 and was eventually incorporated into the CMP during FY91. The objective was to continue sampling for important atmospheric emissions and to characterize the impacts of Basin F remediation. Sampling focused on both VOC and OCP near the Basin and near the storage pond for Basin F liquids.

Continuity with previous Basin F and IRA-F monitoring locations was maintained whenever possible. Sampling locations for the IRA-F addition to the CMP are shown in Figure 3.3-2. Samplers were established on or near the Basin F "perimeter" site (or exclusion zone) locations which were used during the Basin F sampling program. The identical sites for BF1 and BF2 were used, and the sites were renamed FC1 and FC2, respectively, under IRA-F. At site BF3, the monitoring platform was relocated to the east of BF3 on the berm of Basin C during June 1989. Subsequently, the site was renamed FC3. At site BF4, the monitoring platform was moved approximately 30 meters east of the old site, the sampling height was changed to 2 m above the ground, and the site was renamed FC4. A new site was established during the early part of the program at FC5, just north of the storage pond (Pond A).

### 3.3.3 The Air Stripper Monitoring Program

Monitoring of off-gases from an air stripper associated with the ground-water extraction well located near Basin F was performed during FY91. The air stripper was installed as part of the IRA-C program and is located within the Basin A Neck ground-water intercept facility operated under IRA-F. The IRA-E facility consists of a slurry wall located at Eighth Avenue between C and D streets. A network of extraction and reinjection wells are located on opposite sides of the slurry wall, allowing interception, treatment, and replacement of ground-water migrating from Basin A.

The air stripper system consists of an air stripper and activated carbon adsorption units for off-gas emission treatment. Water exiting the air stripper is routed to the IRA-E liquid phase carbon adsorption units. Weekly monitoring of off-gases from the air stripper system was initiated under the IRA-F program and continued under the CMP; however, monitoring was discontinued after April 11, 1991 when the air stripper ceased operation due to low water levels in the Basin F ground-water extraction well.

A more detailed description of the air stripper monitoring program and the results of the FY91 collection period are provided in Section 4.8.

### 3.3.4 Cap and Vent Monitoring

The IRA-F program monitored the integrity of the waste pile and restored basin caps, as well as the potential total emissions from the waste pile, tank farm, and pond vents. Total organics were monitored with an HNu and an OVA monitor at selected grid points on the waste pile and basin caps and at each of the vents on the waste pile, pond and tanks. A detailed description of the cap and vent monitoring program and results are provided in Section 4.9 of this report.

## 3.4 METEOROLOGICAL MONITORING PROGRAM

Meteorological parameters were monitored at four locations within RMA's boundaries. Three stations were established in 1981 and were maintained by RMA. During CMP FY89, a modification to the Technical Plan placed meteorological monitoring and data processing under CMP responsibilities. The network was upgraded to include radio-telemetry from the three original sites to a central computer facility which was also the location of the continuous gaseous monitoring site. A fourth meteorological station was erected at this location. Operation of the upgraded meteorological network was initiated on February 1, 1989, and continued through FY91. Results of the meteorological monitoring program are provided in Section 7.0; detailed data are also shown in Appendix J.

### 3.4.1 Location of Meteorological Monitoring Stations

The separate meteorological monitoring sites were set up to be as close as possible to potentially major sources of contaminants at RMA. These are indicated as M1, M2, M3 and M4 (Figure 3.4-1). A Basin F station (BF) was dismantled in FY89; data were not collected from that tower during FY91.

Meteorological Station 1 (M1) was located in Section 26, approximately 200 yards south of Ninth Avenue and 700 yards west of "D" Street. Meteorological Station 2 (M2) was located in Section 25, north of the North Plants complex, approximately 200 yards south of Ninth Avenue and 700 yards east of "D" Street. Meteorological Station 3 (M3) was located approximately 50 yards north of December Seventh Avenue and 500 yards west

of "E" Street in Section 36. Meteorological Station 4 (M4) was located approximately 15 yards north of Eighth Avenue and 350 yards east of "D" Street in Section 25. The Basin F Station was located west of Basin F in Section 26. The meteorological monitoring stations were previously installed to depict potential local and micrometeorological influences that may occur within the Arsenal compound. One of the objectives of the CMP has been to analyze the collected data and determine air quality impacts, if any, that may result from local topographical differences and the resultant drainage differences within the Arsenal. Results of this analysis have been discussed in previous reports.

### 3.4.2 Monitoring Equipment and Strategy

Monitoring sensors were fixed on 10-meter meteorological towers or at the base of the stations. Wind speed, wind direction, sigma theta, temperature and relative humidity were monitored at 10 m above ground level while solar radiation, barometric pressure and precipitation were all monitored at the surface. Temperature was monitored at M1 at both the 10 m and 2 m levels, and temperature difference (10 m - 2 m) between the two sensors was calculated. A depiction of parameters monitored at each site is shown in Table 3.4-1.

### 3.4.3 Data Acquisition

Meteorological data were downloaded automatically each night from each CMP site onto the base computer through telemetry, modems and phone lines. This database was closely checked each day by CMP personnel.

### 3.4.4 Data Applications

Meteorological data were used in several ways during the CMP. Wind speed, wind direction and temperature were used to select sampling days and identify high event periods favorable for collection of contaminants. Temperature and barometric pressure were used to compute standardized volumes for air quality data. All parameters, including atmospheric stability and precipitation data, were collected and compared with long-term regional data in order to determine the representativeness of the sampling

period. The on-site meteorological data was used in atmospheric dispersion modeling to compare monitored air quality data with predicted impacts assuming RMA emission sources as the primary contributors.

## 3.5 CONTINUOUS AIR MONITORING PROGRAM

The continuous air monitoring station was located within the RMA boundaries, approximately 350 yards east and 50 yards north of the intersection of Eighth Avenue and "D" Street. For a second point of reference, this station was located 100 ft. north-northeast of Meteorological Tower M4 (Figure 3.4-1).

The Continuous Air Monitoring Program was designed to monitor the so-called criteria or "regulated" pollutants, including carbon monoxide (CO), ozone ($O_3$), sulfur dioxide ($SO_2$), and nitrogen dioxide ($NO_2$). In accordance with EPA guidance for monitoring these pollutants, the data were monitored continuously, with digital retrieval on an automated data acquisition system every 2 seconds and storage of hourly averages. Analog chart records were used as a back-up data source. Although nitric oxide (NO) and nitrogen oxides (NOx) are not designated as criteria pollutants, their values were also reported. When summarized, the data represent virtually a continuous recording of ambient air quality. A list of the parameters monitored, along with the analyzer model number, the full scale range, method of detection, the EPA sampling method and data recovery percentage is summarized in Table 3.5-1.

## 3.6 LABORATORY ANALYSIS PROGRAM

The objective of the laboratory analysis program was to provide PMRMA with reliable, statistically supportable, and legally defensible air quality data for airborne contaminants at RMA. Laboratory analysis procedures (except those for TSP, PM-10, and asbestos) were reviewed and certified by PMRMA. Volatile organic compounds were analyzed by certified semi-quantitative GC/MS methods. OCP (aldrin, chlordane, dieldrin, endrin, isodrin, PPDDE and PPDDT), ICAP metals (cadmium, chromium, copper, lead and zinc) and other metals (arsenic and mercury) were analyzed by certified quantitative methods. TSP, PM-10 and asbestos analyses were determined using standard NIOSH and EPA analytical methods.

The target analytes for the program were selected from an evaluation of contaminant sources at RMA, the compounds associated with previous activities at these sites, and compounds previously detected in past air, soil, and water monitoring investigations. Table 3.6-1 lists the analyses, along with the type of certification procedure, the reference method and the type of analytical method. These methods are described in some detail in Section 3.2.4.

The defensibility and technical quality of data generated in this program were assured by documenting all the analytical procedures and by requiring all data to exceed minimum analysis method requirements with respect to instrument calibration and quality control. Sample preparation, materials shipping, handling, and chain-of -custody procedures followed the protocol outlined in the Quality Assurance/Quality Control Manual for the CMP (RLSA, 1988 and WCC, 1992). These are discussed further in Section 8.0.

For each target compound, there is a lower certified reporting limit (CRL). This CRL refers to the lower detection limit of the analytical technique that can assure a 95 percent confidence limit of positive detection. The CRL is based on a mass per sample and is limited by instrumentation and methodology. Below this limit, any laboratory detection must be regarded as not detected or below the CRL. Table 3.6-2 lists the compounds and groups of compounds along with their lower CRL. Note that within the VOC group, there is a wide range of lower CRL which vary according to target analyte sensitivity in relation to the method employed. Also provided in Table 3.6-2 is a detection limit converted to atmospheric concentration based on the reported lower CRL and an estimated target volume for each sample group.

There is also an upper certified reporting limit (UCRL) for each target compound. The CRL and UCRL define the accepted linear range for each target analyte, and is limited by instrumentation and methodology. Any detection above the UCRL must be labelled as an estimated value since it falls outside of the certified linear range.

## TABLE 3.2-1

## SAMPLING LOCATIONS

| Location | Site ID | Start Date | End Date | Northing Easting Coordinates | | Elevation | COC ID |
|---|---|---|---|---|---|---|---|
| **Locations of OCP High Event Sample Sites Other Than Permanent CMP Sites (FY91)** | | | | | | | |
| Quench Incinerator | Mobile East | 06/20/91 | 06/21/91 | 190100.00 | 2183700.00 | 5218.00 | CAQ25002 |
| South Plants | Mobile East | 06/26/91 | 06/27/91 | 179000.00 | 2184800.00 | 5260.00 | CAQ01074 |
| South Plants | Mobile South | 06/26/91 | 06/27/91 | 178950.00 | 2184600.00 | 5260.00 | CAQ01075 |
| South Plants | Mobile West | 06/26/91 | 06/27/91 | 179050.00 | 2184400.00 | 5260.00 | CAQ01076 |
| **Locations of VOC High Event Sample Sites Other Than Permanent CMP Sites (FY91)** | | | | | | | |
| Quench Incinerator | Mobile East | 06/20/91 | 06/21/91 | 190100.00 | 2183700.00 | 5210.00 | CAQ25003 |
| South Plants | Mobile East | 06/26/91 | 06/27/91 | 179000.00 | 2184800.00 | 5260.00 | CAQ01083 |
| South Plants | Mobile South | 06/26/91 | 06/27/91 | 178950.00 | 2184600.00 | | |
| South Plants | Mobile South | 06/26/91 | 06/27/91 | 178950.00 | 2184600.00 | 5260.00 | CAQ01084 |
| South Plants | Mobile West | 06/26/91 | 06/27/91 | 179050.00 | 2184400.00 | 5260.00 | CAQ01086 |
| **Locations of Mercury/Metals High Event Sample Sites Other Than Permanent CMP Sites (FY91)** | | | | | | | |
| Quench Incinerator | Mobile East | 05/14/91 | 05/15/91 | 190100.00 | 2183700.00 | 5210.00 | CAQ25001 |
| Quench Incinerator | Mobile West | 05/14/91 | 05/15/91. | 190100.00 | 2183000.00 | 5210.00 | CAQ26011 |

## TABLE 3.2-1
## (Continued)

| Location | Site ID | Start Date | End Date | Northing Easting Coordinates | | Elevation | COC ID |
|---|---|---|---|---|---|---|---|
| Quench Incinerator | Mobile East | 07/02/91 | 07/03/91 | 190100.00 | 2183700.00 | 5210.00 | CAQ25004 |
| Basin A | Mobile East | 07/11/91 | 07/11/91 | 182300.00 | 2187100.00 | 5245.00 | CAQ36017 |
| Basin A | Mobile East | 07/11/91 | 07/11/91 | 182300.00 | 2187100.00 | 5245.00 | CAQ36018 |
| Basin A | Mobile West | 07/11/91 | 07/11/91 | 183200.00 | 2183700.00 | 5245.00 | CAQ35012 |
| South Plants | Mobile East | 07/17/91 | 07/18/91 | 178900.00 | 2183900.00 | 5260.00 | CAQ01078 |
| South Plants | Mobile East | 07/17/91 | 07/18/91 | 178900.00 | 2183900.00 | 5260.00 | CAQ01079 |
| South Plants | Mobile West | 07/17/91 | 07/18/91 | 179200.00 | 2183500.00 | 5270.00 | CAQ02013 |
| **Surveyed Locations for Permanent CMP Sites Used During High Event and/or Routine Sampling (FY91)+** | | | | | | | |
| | AQ1 | | | 179894.09 | 2168044.46 | 5172.90 | |
| | AQ2 | | | 190950.25 | 2173808.13 | 5131.03 | |
| | AQ3 | | | 195895.65 | 2185671.67 | 5141.14 | |
| | AQ4 | | | 180536.12 | 2196630.92 | 5299.22 | |
| | AQ5 | | | 170517.42 | 2178593.75 | 5266.50 | |
| | AQ6 | | | 177674.96 | 2183761.74 | 5259.90 | |
| | AQ7 | | | 178246.45 | 2174165.98 | 5196.10 | |
| | AQ8 | | | 180741.57 | 2184793.38 | 5263.93 | |
| | AQ9 | | | 185767.70 | 2185937.88 | 5271.20 | |
| | AQ10 | 10/01/89 | 04/19/90 | 190814.11 | 2180111.40 | 5190.80* | |
| | AQ10a | 04/20/90 | 09/04/90 | 185800.00 | 2183550.00 | 5240.00* | |

**TABLE 3.2-1**
**(Concluded)**

| Location | Site ID | Start Date | End Date | Northing Easting Coordinates | | Elevation | COC ID |
|---|---|---|---|---|---|---|---|
| | AQ10b | 09/05/90 | 09/30/90 | 178950.00 | 2183850.00 | 5265.00* | |
| | AQ11 | | | 190596.94 | 2181735.99 | 5192.00 | |
| | AQ12 | | | 190620.16 | 2186724.88 | 5186.02 | |
| | FC1 | | | 190812.80 | 2180129.05 | 5191.10 | |
| | FC2 | | | 189877.06 | 2181324.36 | 5204.4 | |
| | FC3 | | | 187997.29 | 2180259.12 | 5209.8 | |
| | FC4 | | | 189688.41 | 2179373.28 | 5193.4 | |
| | FC5 | | | 191232.76 | 2180501.15 | 5187.9 | |
| | QI1 | | | 192000 | 2183312.00 | 5190*** | |
| | QI1 | | | 189500 | 2183250.00 | 5200*** | |
| | MET1 | | | 190632.43 | 2181737.97 | 5192.43 | |
| | MET2 | | | 190523.61 | 2186253.84 | 5193.76 | |
| | MET3 | | | 180733.49 | 2187492.58 | 5263.19 | |
| | MET4 | | | 185997.34 | 2184581.95 | 5278.70 | |
| | AQ SITE | | | 186089.28 | 2184630.75 | 5278.54 | |

+ All permanent stations were operational from 01/21/91 to 09/30/91.

* AQ10 is considered a mobile sampling site for the CMP. This site was relocated twice during FY90 to allow more efficient sampling. The most recent locations are not surveyed, but estimated.

** All elevations for the Mobile Sites are estimated using a 7-1/2 minute Quadrant USGS Topographical Map.

*** QI1 and QI2 are estimated since surveying has not been completed.

## TABLE 3.2-2

## PARAMETER AND STRATEGIES FOR CMP AIR MONITORING PROGRAM - FY91

| Parameter | Type | Frequency | Location | No. of Samples | No. of Collocated[f] | No. of Blanks | Total Samples |
|---|---|---|---|---|---|---|---|
| TSP | Baseline | 6th day | AQ1,2,3,4,5,6,7,8,9,11,12 QI1,2 and portable station AQ10 | 578[a] | 43 | 43 | 664 |
| TSP | Baseline | 12th day | FC1,2,3,4,5 | 89[c,d] | | | 89 |
| Metals Arsenic | Baseline | 6th day | AQ2,3,5 and QI1,2 | 150[a] | 28[a] | 43 | 221 |
| Metals Arsenic | Baseline | 12th day | FC1,2,3,4,5 | 89[c,d] | | | 89 |
| PM10 | Baseline | 6th day | AQ1,2,3,5,9,10 and QI1,2 | 320[a] | 43 | | 363 |
| PM10 | Baseline | 12th day | FC1,3 | 28[h] | | | 28 |
| VOC | Baseline | 6th day | AQ2,3,5 and FC1,2,3,4,5 and QI1,2 | 352[c,d,e] | 43 | 43 | 438[k]<br>43[b] |
| OCP | Baseline | 6th day | AQ2,3,5 and FC1,2,3,4,5 and QI1,2 | 348[c,d,e] | 43 | 43 | 434[k] |
| OCP | Baseline | 12th day | AQ1 | 16 | | | 16 |
| Metals Arsenic | High Event (Approx. 1 per month) | 6 Events | AQ1,3,4,5 and 4 mobile or other fixed station as appropriate | 48 | 6 | 6 | 60 |
| Mercury | High Event (Approx. 1 per month) | 6 Events | AQ1,3,4,5 and 4 mobile or other fixed station as appropriate | 48 | 6 | 6 | 60 |
| VOC | High Event | 3 Events | AQ1,3,4,5 and 4 mobile or other fixed station as appropriate | 24 | 3 | 3 | 30<br>3[b] |
| OCP | High Event | 3 Events | AQ1,3,4,5 or other fixed and mobile stations as appropriate | 12 | 3 | 3 | 18 |
| Asbestos | High Event | 2 Events | AQ1,6,8,12 | 8 | 2 | 4[i] | 14 |
| Air Quality[g] | Baseline | Continuous | MET4 | 6000 hourly averages[j] | | | 6000 |

# TABLE 3.2-2
## (Concluded)

[a] Collocated sampling of Metals/Arsenic is at a frequency of 10% of the total number of samples.
[b] Represents 1 out of every 10 Tenax/Charcoal tubes that will be analyzed.
[c] Site FC2 was reinstated on March 1, 1991 on a 12th day schedule for TSP, OCP and VOC.
[d] Sites FC3 and FC4 were reduced to once a month schedule on March 31, 1991 for TSP, OCP and VOC.
[e] Sites QI1 and QI2 were installed for March 31, 1991 sample period to monitor the Incineration Construction. Both sites will follow the 6th day schedule for TSP, Metals, Arsenic, OCP, PM10 and VOC.
[f] TSP and PM10 collocated samples were collected at AQ5. OCP and VOC collocated samples were collected at FC1. All other collocated samples were located with respect to suspected containment source proximity and logistical suitability.
[g] Includes monitoring of ozone, carbon monoxide, sulfur dioxide, nitric oxide, nitrogen dioxide and nitrogen oxides.
[h] PM10 sampling at FC3 ended on March 31, 1991.
[i] Two blanks per sampling event.
[j] Based on 250 24 hour periods from 0100z on January 23, 1991 through 2400z on September 30, 1991. Individual parameter hours differ due to "on line" sampling after calibrations. (SO2 6036; CO 6056; O3 6057; NO/NO2/NOx 6008).
[k] Efficiency spikes; includes 3 spikes and 2 controls. Spiking was completed in 2 samplings.

## TABLE 3.2-3

## SAMPLING STRATEGIES FOR HIGH EVENT AIR QUALITY MONITORING

| Atmospheric Parameter | High Event Conditions[1] | | |
|---|---|---|---|
| | VOC/SVOC | Alternate[2] SVOC | Metals |
| Wind Speed | < 5 mph | > 10 mph | > 10 mph |
| Temperature | > 75° F | > 75° F | N/A |
| Relative Humidity | < 50% | N/A | N/A |
| Precipitation | None | None | None |
| Soil Moisture | Dry | Dry | Dry |
| Snow Cover | None | None | None |

1 These are approximate values for defining favorable monitoring conditions. When all or most conditions are met for a particular contaminant, samples should be collected.

2 Two or three samples will be collected under this scenario.

## TABLE 3.4-1

## METEOROLOGICAL PARAMETERS MONITORED AT RMA DURING FY91

| | Site | | | |
|---|---|---|---|---|
| Parameter | M1 | M2 | M3 | M4 |
| Wind Speed | X | X | X | X |
| Wind Direction | X | X | X | X |
| Sigma Theta* | X | X | X | X |
| Temperature | X | X | X | X |
| Temperature (2-meters) | X | | | |
| Relative Humidity | X | | | |
| Barometric Pressure | | | | X |
| Solar Radiation | | X | X | |
| Precipitation | X | X | X | X |

* A computed value equivalent to a running average standard deviation of wind direction.

## TABLE 3.5-1

## RMA CONTINUOUS GASEOUS AIR MONITORING PROGRAM SUMMARY

| Parameter and Full Scale Range | Analyzer Used | Method of Detection | EPA Sampling Method | Recent Recovery of Hourly Values |
|---|---|---|---|---|
| Carbon Monoxide* (CO) 50.0 ppm | TECO Model - 48 | Gas Filter Correlation | RFCA-0981-054 September, 1981 | 96.5 |
| Ozone** (O3) 1.0 ppm | TECO Model - 49 | Time-shared Dual Cell U.V. Photometric | EQOA-0880-047 August 27, 1980 | 90.5 |
| Sulfur Dioxide* (SO2) 0.5 ppm | TECO Model - 43A | Pulsed Fluorescent | ESQA-0486-060 February 18, 1975 | 92.1 |
| Nitric Oxide* (NO) 0.5 ppm | TECO Model - 14B/E | Chemiluminescent | No Method Available | 97.7 |
| Nitrogen Dioxide* (NO2) 0.5 ppm | TECO Model - 14B/E | Chemiluminescent | As specified in 40 CFR, Part 53*** | 97.7 |
| Oxides of Nitrogen ($NO_x$) 0.5 ppm | TECO Model - 14B/E | Chemiluminescent | No Method Available | 97.7 |

* System used for calibration includes TECO Model - 146 Multigas Dilution Calibrator, TECO Model - 111 Zero Air Supply, and a span gas source traceable to EPA protocol #2 (U.S. EPA, 1987).

** System used for calibration includes TECO Model - 146 Multigas Dilution Calibrator, TECO Model - 111 Zero Air Supply, and TECO Model - 49PS Photometric Ozone Source Calibrator.

*** Analyzer must be operated on 0 to 0.500 ppm range scale.

## TABLE 3.6-1

## ANALYTICAL METHODS FOR AIR QUALITY MONITORING PROGRAM

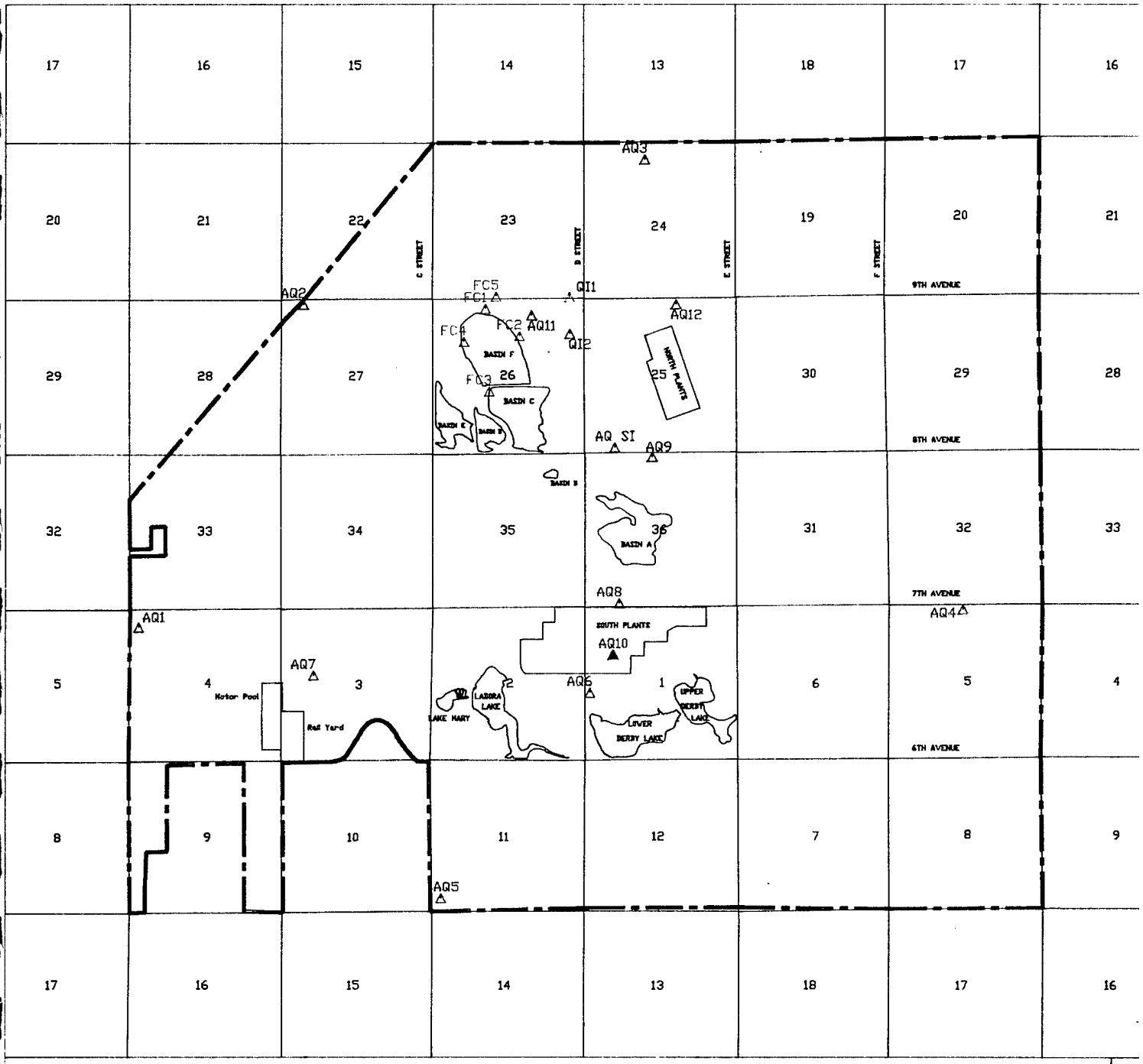
| Parameter | Certification | Reference Methods | Certification Method | PMRMA Method Number |
|---|---|---|---|---|
| TSP | None | 40 CFR Part 50 Appendix B | Gravimetric | |
| PM-10 | None | 40 CFR, Part 50 Appendix B | Gravimetric | |
| Asbestos | None | NIOSH 7400 | Phase Contrast Microscopy | |
| VOC | Semi-quantitative | EPA TO-1 with EPA Method 624 | GC/MS | CM04 |
| SVOC | Semi-quantitative | EPA Method TO-4 | GC/MS | CM03 |
| OCP | Quantitative | Modified EPA Method 608 | GC/ECD | CH01 |
| Metals | Quantitative | NIOSH 7300 | ICAP | AS01 |
| Lead | Quantitative | 40 CFR Part 50, Appendix G | ICAP | |
| Arsenic | Quantitative | EPA Method 206.2, 1979 | AA-Graphite Furnace | AD03 |
| Mercury | Quantitative | AIHA, 1976 | AA-Cold Vapor | AB01 |

## TABLE 3.6-2

## ANALYTES AND CERTIFIED REPORTING LIMITS FOR AIR QUALITY MONITORING PROGRAM

| Parameter | Certified Reporting Limit (Lower Certified Range) | Atmospheric Detection Limit |
|---|---|---|
| TSP | 2 $\mu g^*$ | 0.001 $\mu g/m^3$ |
| PM-10 | 2 $\mu g^*$ | 0.001 $\mu g/m^3$ |
| Asbestos | 7 fibers/$mm^2$ | 0.002 fibers/ml |
| VOC | 0.012 to 0.149 $\mu g$ | 0.071-1.214 $\mu g/m^3$ |
| OCP | 0.100 $\mu g$ | 0.0004 $\mu g/m^3$ |
| Metals | | |
| cadmium | 4.0 $\mu g$ | 0.0004 $\mu g/m^3$ |
| chromium | 20.0 $\mu g$ | 0.005 $\mu g/m^3$ |
| copper | 8.0 $\mu g$ | 0.009 $\mu g/m^3$ |
| lead | 40.0 $\mu g$ | 0.005 $\mu g/m^3$ |
| zinc | 20.0 $\mu g$ | 0.003 $\mu g/m^3$ |
| Arsenic | 1.41 $\mu g$ | 0.0004 $\mu g/m^3$ |
| Mercury | 0.10 $\mu g$ | 0.809 $\mu g/m^3$ |

$^*$ = Limit is not certified, but is instrument and method dependent.




LEGEND

△ Permanent Air Quality Monitoring Station

▲ Portable Air Monitoring Station

-N-

5000 0 5000 10000

SCALE Feet

Woodward–Clyde Consultants

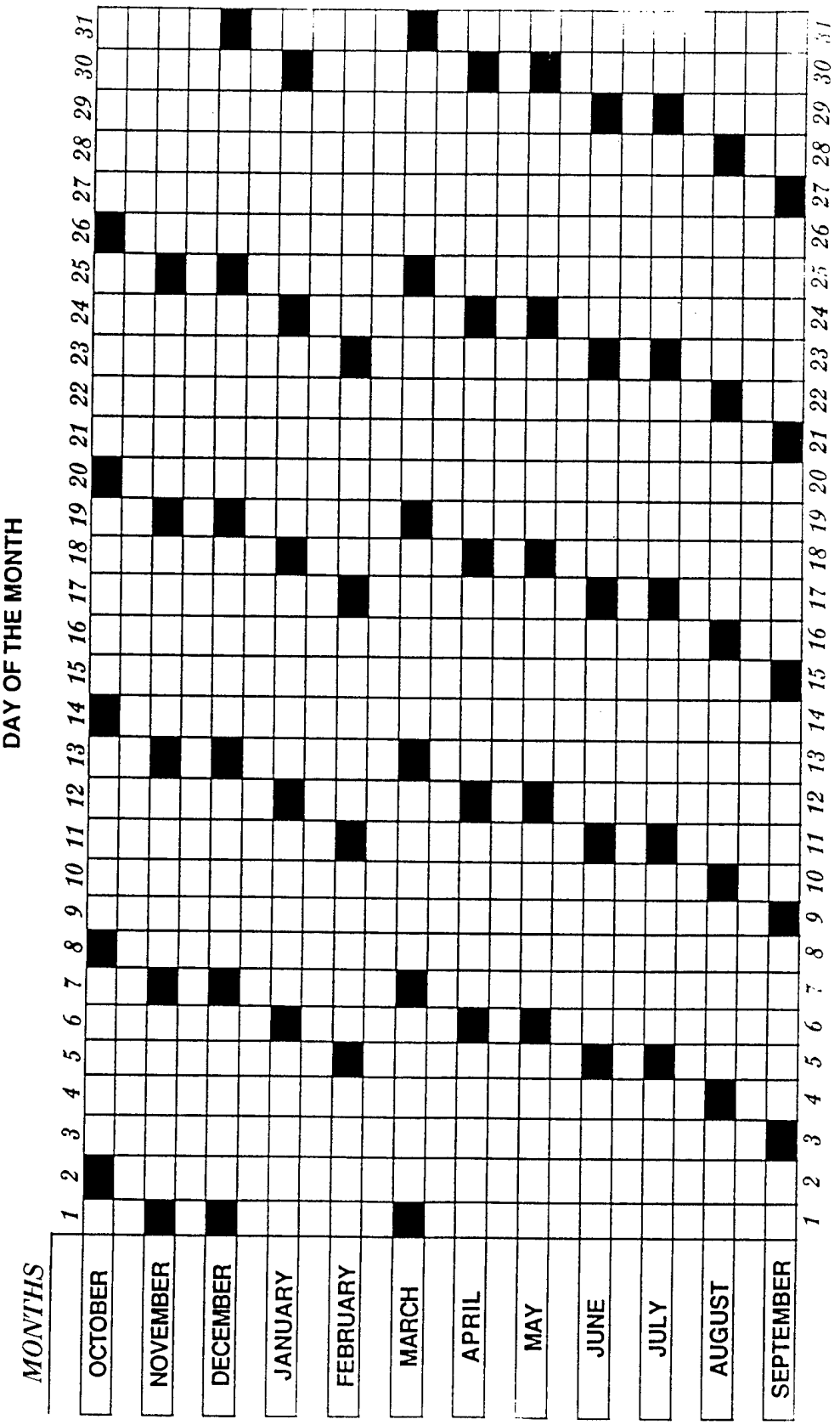
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

# CMP Air Quality Monitoring Stations at Rocky Mountain Arsenal

U.S. Program Manager — Rocky Mountain Arsenal

| | | | |
|---|---|---|---|
| DRWN BY : dwb | DATE : 5/5/92 | PROJECT NO: 22787E | FIG. NO : 3.2–1 |
| CHKD BY : . | DATE : . | | |

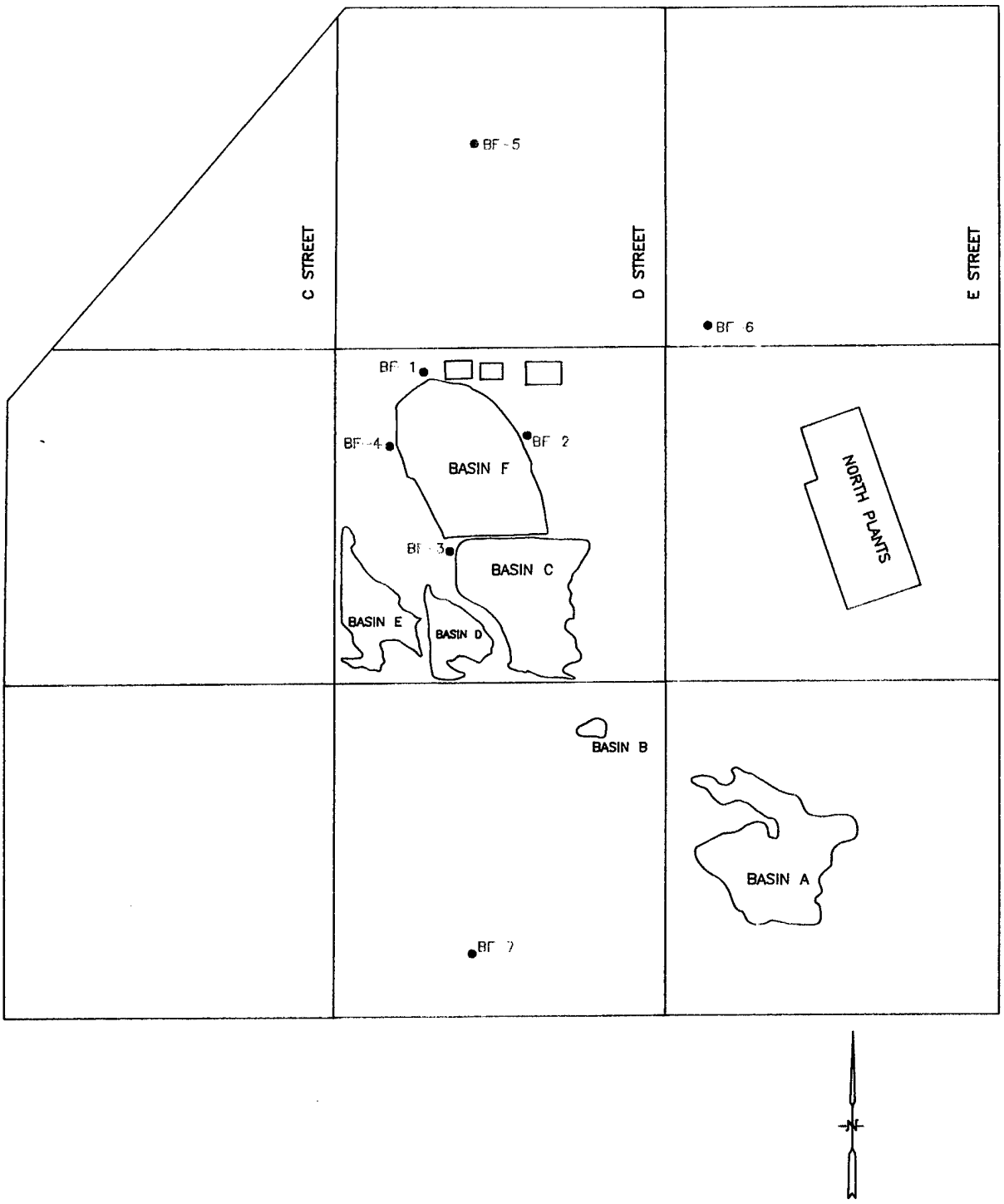
FY91 AIR SAMPLING SCHEDULE
DAY OF THE MONTH




| | |
|---|---|
| Job No. : | 22787E |
| Prepared by : | T.R.H. |
| Date : | 10/20/92 |

**NATIONAL AMBIENT AIR QUALITY SAMPLING SCHEDULE FOR 1991**

FIG. 3.2-2







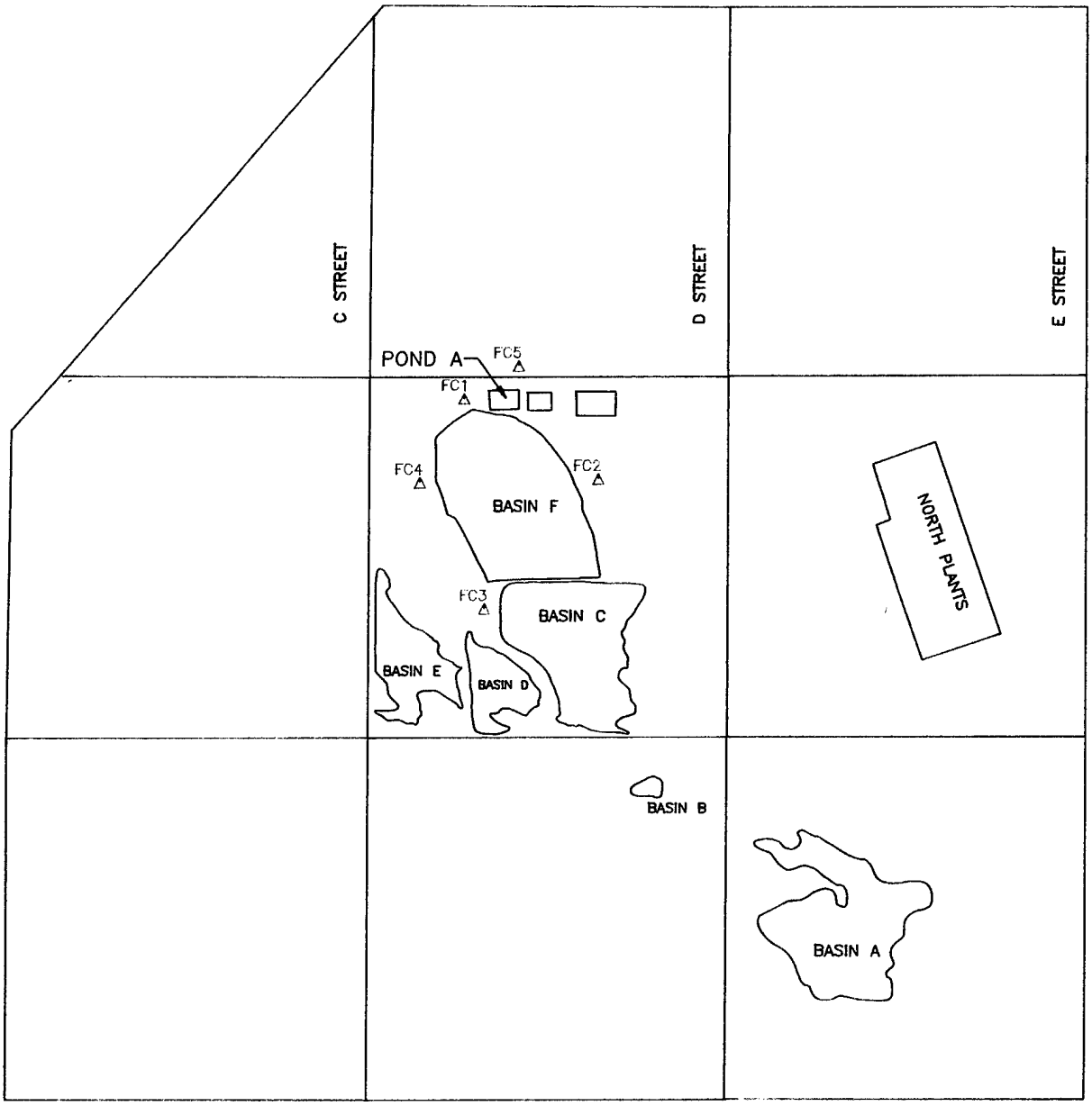
2500 0 2500 5000
SCALE Feet

Woodward–Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

# Location of Basin F Air Quality Monitoring Station at Rocky Mountain Arsenal

U.S. Program Manager — Rocky Mountain Arsenal

| | | | |
|---|---|---|---|
| DRWN BY : dwb | DATE : 5/5/92 | PROJECT NO: 22787E | FIG. NO : 3.3–1 |
| CHKD BY : . | DATE : . | | |




2500 0 2500 5000

SCALE Feet

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# Location of IRA–F Air Quality Monitoring Stations Additions to CMP

U.S. Program Manager — Rocky Mountain Arsenal

| | | | |
|---|---|---|---|
| DRWN BY : dwb | DATE : 5/5/92 | PROJECT NO: 22787E | FIG. NO : 3.3–2 |
| CHKD BY : . | DATE : . | | |


LEGEND

△ Meteorological Monitoring Station

N

5000 0 5000 10000

SCALE Feet

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# RMA Meteorological Monitoring Stations

U.S. Program Manager — Rocky Mountain Arsenal

| | | | |
|---|---|---|---|
| DRWN BY : dwb | DATE : 5/5/92 | PROJECT NO: 22787E | FIG. NO : 3.4–1 |
| CHKD BY : . | DATE : . | | |